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(54) Title: COMPOSITIONS AND METHODS FOR IDENTIFYING AND TARGETING STOMACH AND ESOPHAGEAL CANCER CELLS

(57) Abstract: Screening and diagnostic reagents, kits and methods for stomach or esophageal cancer are disclosed. Compounds, compositions and methods of treating patients with stomach or esophageal cancer and for imaging stomach or esophageal tumors in vivo are disclosed. Compositions and methods for delivering active compounds such as drugs, gene therapeutics and antisense compounds to stomach or esophageal cells are disclosed. Vaccines compositions and methods of for treating and preventing stomach or esophageal cancer are disclosed.

COMPOSITIONS AND METHODS FOR IDENTIFYING AND TARGETING STOMACH AND ESOPHAGEAL CANCER CELLS

FIELD OF THE INVENTION

The present invention relates to *in vitro* diagnostic methods for detecting stomach and esophageal cancer cells, to kits and reagent for performing such methods. The present invention relates to compounds and methods for *in vivo* imaging and treatment of stomach and esophageal tumors. The present invention relates to methods and compositions for making and using targeted gene therapy, antisense and drug compositions. The present invention relates to prophylactic and therapeutic anti-stomach and esophageal cancer vaccines and compositions and methods of making and using the same.

BACKGROUND OF THE INVENTION

There is a need for reagents, kits and methods for screening, diagnosing and monitoring individuals with stomach or esophageal cancer, including metastasized stomach and esophageal cancer. There is a need for reagents, kits and methods for identifying and confirming that a cancer of unknown origin is stomach or esophageal cancer and for analyzing tissue and cancer samples to identify and confirm stomach or esophageal cancer and to determine the level of migration of such cancer cells. There remains a need for compositions which can specifically target stomach and esophageal cancer cells. There is a need for imaging agents which can specifically bind to stomach and esophageal cancer cells. There is a need for improved methods of imaging stomach and esophageal cancer

cells. There is a need for therapeutic agents which can specifically bind to stomach and esophageal cancer cells. There is a need for improved methods of treating individuals who are suspected of suffering from stomach or esophageal cancer cells, especially individuals who are suspected of suffering from metastasis of stomach or esophageal cancer cells. There is a need for vaccine composition to treat and prevent metastasized stomach and esophageal cancer. There is a need for therapeutic agents which can specifically deliver gene therapeutics, antisense compounds and other drugs to stomach and esophageal cancer cells.

SUMMARY OF THE INVENTION

The invention further relates to *in vitro* methods of determining whether or not an individual has stomach or esophageal cancer cells. The present invention relates to *in vitro* methods of examining samples of non-colorectal tissue and body fluids from an individual to determine whether or not CRCA-1, which is expressed by normal and cancerous colon cells and stomach and esophageal tumor cells, is being expressed by cells in samples other than colon. The presence of a CRCA-1 translation product or of the CRCA-1 transcript in samples outside the colorectal track is indicative of expression of CRCA-1 and is evidence that the individual may be suffering from metastasized colon cancer or stomach and esophageal cancer.

The invention further relates to *in vitro* methods of determining whether or not tumor cells are stomach or esophageal in origin. The present invention relates to *in vitro* methods of diagnosing whether or not an individual suffering from cancer is suffering from stomach or esophageal cancer. The present invention relates to *in vitro* methods of examining samples of tumors from an individual to determine whether or not CRCA-1, which is expressed by stomach or esophageal tumor cells, is being expressed by the tumor cells. The presence of a CRCA-1 translation product or of the CRCA-1 transcript is indicative of expression of CRCA-1 is evidence that the individual may be suffering from stomach or esophageal cancer.

The invention further relates to *in vitro* kits for practicing the methods of the invention and to reagents and compositions useful as components in such *in vitro* kits of the invention.

The invention further relates to a method of imaging stomach and esophageal tumors and to methods of treating an individual suspected of suffering from stomach and esophageal cancer comprising the steps of administering to said individual a pharmaceutical compositions according to the invention, wherein the compositions or conjugated compounds are present in an amount effective for therapeutic or diagnostic use in humans suffering from stomach or esophageal cancer.

The invention further relates to a method of delivering an active agent to stomach and esophageal cancer cells comprising the steps of administering to an individual who has stomach or esophageal cancer, a pharmaceutical composition comprising a pharmaceutically acceptable carrier or diluent, and an unconjugated compositions that comprises a liposome that includes CRCA-1 translation product ligands on its surface and an active component encapsulated therein.

The invention further relates to killed or inactivated stomach or esophageal tumor cells that comprise a protein comprising at least one epitope of a CRCA-1 translation product; and to vaccines comprising the same. In some embodiments, the killed or inactivated cells or particles comprise a CRCA-1 translation product. In some embodiments, the killed or inactivated cells or particles are haptenized.

The invention further relates to methods of treating individuals suffering from metastasized stomach or esophageal cancer and to methods of treating individuals susceptible metastasized stomach or esophageal cancer. The method of the present invention provides administering to such individuals an effective amount of such vaccines. The invention further relates to the use of such vaccines as immunotherapeutics.

BRIEF DESCRIPTION OF THE FIGURE

Figure 1 shows the nucleotide sequence of the human ST receptor mRNA, GeneBank Accession #S57551, which is incorporated herein by reference. The gray shaded area is the sequence deleted in CRCA-1 transcript including on of the two boxed "GG" sequences or one G from each box. The start codon, ATG, which is nucleotides 118-119-120 of the sequence is the intiation codon for ST receptor protein expression. The CRCA-1 transcript is missing a 142 nucleotide sequence spanning nucleotides 192-333,

193-334 or 194-335. Thus unique sequences of the CRCA-1 protein not found ST receptor mRNA include nucleotides 191-192-193-336, 191-192-335-336 or 191-334-335-336 as set forth in Figure 1 or using corresponding numbers from sequences set forth in the sequence listing. These 4 nucleotide sequences are all identical, A-G-G-C, and correspond to nucleotides 110-111-112-113 of SEQ ID NO:1.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

This application is related to U.S. Serial Number 08/908,643 filed August 7, 1997, which is incorporated herein by reference. This application is also related to U.S. Provisional Application, Serial Number 60/192,229, filed March 27, 2000, which is incorporated herein by reference.

Definitions

As used herein, the terms "ST" and "native ST" are used interchangeably and are meant to refer to heat-stable toxin (ST) which is a peptide produced by *E. coli*, as well as other organisms. STs are naturally occurring peptides which 1) are naturally produced by organisms, 2) bind to the ST receptor and 3) activate the signal cascade that mediates ST-induced diarrhea.

As used herein, the terms "ST receptor", "guanylyl cyclase C receptor" and "GCC receptor" are meant to refer to the receptors found on colorectal cells, including local and metastasized colorectal cancer cells, which bind to ST. In normal individuals, ST receptors are found exclusively in cells of intestine, in particular in cells in the duodenum, small intestine (jejunum and ileum), the large intestine, colon (cecum, ascending colon, transverse colon, descending colon and sigmoid colon) and rectum.

As used herein, the terms "colorectal cancer-associated transcript" and "CRCA-1 transcript" are meant to refer to an alternative form of the mRNA for the ST receptor produced by transcription of the human ST receptor gene. The CRCA-1 transcript possesses an alternative sequence from that of the ST receptor encoding-mRNA. CRCA-1 transcript preferably has a nucleotide sequence set forth in SEQ ID NO:1. CRCA-1 transcript is found in colorectal cells, including local and metastasized colorectal cancer cells. In normal individuals, CRCA-1 transcript have been found exclusively in cells of intestine, in particular in cells in the duodenum, small intestine (jejunum and ileum), the

large intestine, colon (cecum, ascending colon, transverse colon, descending colon and sigmoid colon) and rectum.

As used herein, the term "functional fragment" as used in the term "functional fragment of a CRCA-1 transcript product" is meant to fragments of CRCA-1 transcript which are functional with respect to nucleic acid molecules with full length sequences. For example, a functional fragment may be useful as an oligonucleotide or nucleic acid probe, a primer, an antisense oligonucleotide or nucleic acid molecule or a coding sequence. Functional fragments of the CRCA-1 transcript are unique compared to other known nucleic acid molecules, in particular functional fragments of the CRCA-1 transcript are unique compared to nucleic acid sequence of the ST receptor mRNA. The nucleotide sequence encoding human ST receptor protein is disclosed in Figure 1, SEQ ID NO:82 and F.J. Sauvage *et al.* 1991 *J. Biol. Chem.* 266:17912-17918 which are incorporated herein by reference. The deleted sequence which results in the generation of the CRCA-1 transcript is disclosed in Figure 1. Thus, the functional fragments of the CRCA-1 include specific sequences not found on the ST receptor mRNA. Such unique sequences include the sequences on either side of the deletion thus forming a unique sequence relative to the ST receptor mRNA sequence. Accordingly, a functional fragment will include nucleotides 110-113 of SEQ ID NO:1. It is preferred that the unique sequence additionally include 5-10 or more sequences 5' to nucleotide 110 and 5-10 or more sequences 3' to nucleotide 113. Oligonucleotides and other fragments of the CRCA-1 transcript which have sequences of function fragments include nucleotides 110-113 of SEQ ID NO:1 and ma additionally include sequences 5' and 3' to the unique four nucleotide sequences formed by the deletion. For example, a PCR primer having 8-28 nucleotides including a unique sequence for CRCA-1, i.e. a functional fragment having 8 nucleotides may include nucleotide sequence 106-113 or 110-117 or an 8 nucleotide sequence generated from the intermediate sequences, i.e. 107-114, 108-115 or 109-116, or a functional fragment having 28 nucleotides may include nucleotide sequence 86-113 or 110-137 or a 28 nucleotide sequence generated from the intermediate sequences. Similarly, other functional fragments of CRCA-1 transcript would include 110-113 of SEQ ID NO:1 as part of a fragment of SEQ ID NO:1. With respect to CRCA-1 specific primers, sets of such primers may include one unique fragment of CRCA-1 transcript and

one primer which is not specific for a unique CRCA-1 sequence provided that such a pair of primers can be used to amplify a CRCA-1 specific sequence.

As used herein, the terms "colorectal cancer-associated translation products" and "CRCA-1 translation products" are meant to refer to translation products set forth in SEQ ID NOs:2-81.

As used herein, the term "functional fragment" as used in the term "functional fragment of a CRCA-1 translation product" is meant to fragments of CRCA-1 translation products which function in the same manner as proteinaceous compounds with full length sequences. For example, an immunogenically functional fragment of a CRCA-1 comprises an epitope recognized by an anti-CRCA-1 translation product antibody. A ligand-binding functional fragment of a CRCA-1 comprises a sequence which forms a structure that can bind to a ligand which recognizes and binds to a CRCA-1 translation product.

As used herein, the term "epitope recognized by an anti-CRCA-1 translation product antibody" refers those epitopes recognized by an anti-CRCA-1 translation product antibody which does not recognize epitopes of non-CRCA-1 translation products, i.e. does not cross react with non-CRCA-1 proteins.

As used herein, the term "antibody" is meant to refer to complete, intact antibodies, and Fab fragments and $F(ab)_2$ fragments thereof. Complete, intact antibodies include monoclonal antibodies such as murine monoclonal antibodies, chimeric antibodies and humanized antibodies.

As used herein, the term "CRCA-1 translation product ligand" is meant to refer to compounds which specifically bind to a CRCA-1 translation product. Antibodies that bind to a CRCA-1 translation product are CRCA-1 translation product ligands. An CRCA-1 translation product ligand may be a protein, peptide or a non-peptide.

As used herein, the term "active agent" is meant to refer to compounds that are therapeutic agents or imaging agents.

As used herein, the term "radiostable" is meant to refer to compounds which do not undergo radioactive decay; i.e. compounds which are not radioactive.

As used herein, the term "therapeutic agent" is meant to refer to chemotherapeutics, toxins, radiotherapeutics, targeting agents or radiosensitizing agents.

As used herein, the term "chemotherapeutic" is meant to refer to compounds that, when contacted with and/or incorporated into a cell, produce an effect on the cell including causing the death of the cell, inhibiting cell division or inducing differentiation.

As used herein, the term "toxin" is meant to refer to compounds that, when contacted with and/or incorporated into a cell, produce the death of the cell.

As used herein, the term "radiotherapeutic" is meant to refer to radionuclides which when contacted with and/or incorporated into a cell, produce the death of the cell.

As used herein, the term "targeting agent" is meant to refer compounds which can be bound by and or react with other compounds. Targeting agents may be used to deliver chemotherapeutics, toxins, enzymes, radiotherapeutics, antibodies or imaging agents to cells that have targeting agents associated with them and/or to convert or otherwise transform or enhance co-administered active agents. A targeting agent may include a moiety that constitutes a first agent that is localized to the cell which when contacted with a second agent either is converted to a third agent which has a desired activity or causes the conversion of the second agent into an agent with a desired activity. The result is the localized agent facilitates exposure of an agent with a desired activity to the cancer cell.

As used herein, the term "radiosensitizing agent" is meant to refer to agents which increase the susceptibility of cells to the damaging effects of ionizing radiation. A radiosensitizing agent permits lower doses of radiation to be administered and still provide a therapeutically effective dose.

As used herein, the term "imaging agent" is meant to refer to compounds which can be detected.

As used herein, the term "CRCA-1 translation product binding moiety" is meant to refer to the portion of a conjugated compound that constitutes an CRCA-1 translation product ligand.

As used herein, the term "active moiety" is meant to refer to the portion of a conjugated compound that constitutes an active agent.

As used herein, the terms "conjugated compound" and "conjugated composition" are used interchangeably and meant to refer to a compound which comprises an CRCA-1 translation product binding moiety and an active moiety and which is capable

of binding to the CRCA-1 translation product. Conjugated compounds according to the present invention comprise a portion which constitutes an CRCA-1 translation product ligand and a portion which constitutes an active agent. Thus, conjugated compounds according to the present invention are capable of specifically binding to the CRCA-1 translation product and include a portion which is a therapeutic agent or imaging agent. Conjugated compositions may comprise crosslinkers and/or molecules that serve as spacers between the moieties.

As used herein, the terms "crosslinker", "crosslinking agent", "conjugating agent", "coupling agent", "condensation reagent" and "bifunctional crosslinker" are used interchangeably and are meant to refer to molecular groups which are used to attach the CRCA-1 translation product ligand and the active agent to thus form the conjugated compound.

As used herein, the term "colorectal cancer" is meant to include the well-accepted medical definition that defines colorectal cancer as a medical condition characterized by cancer of cells of the intestinal tract below the small intestine (i.e. the large intestine (colon), including the cecum, ascending colon, transverse colon, descending colon, and sigmoid colon, and rectum). Additionally, as used herein, the term "colorectal cancer" is meant to further include medical conditions which are characterized by cancer of cells of the duodenum and small intestine (jejunum and ileum). The definition of colorectal cancer used herein is more expansive than the common medical definition but is provided as such since the cells of the duodenum and small intestine also contain CRCA-1 translation products.

As used herein, the term "metastasis" is meant to refer to the process in which cancer cells originating in one organ or part of the body relocate to another part of the body and continue to replicate. Metastasized cells subsequently form tumors which may further metastasize. Metastasis thus refers to the spread of cancer from the part of the body where it originally occurs to other parts of the body.

As used herein, the term "metastasized colorectal cancer cells" is meant to refer to colorectal cancer cells which have metastasized; colorectal cancer cells localized in a part of the body other than the duodenum, small intestine (jejunum and ileum), large

intestine (colon), including the cecum, ascending colon, transverse colon, descending colon, and sigmoid colon, and rectum.

As used herein, the term "non-colorectal sample" and "extra-intestinal sample" are used interchangeably and meant to refer to a sample of tissue or body fluid from a source other than colorectal tissue. In some preferred embodiments, the non-colorectal sample is a sample of tissue such as lymph nodes. In some preferred embodiments, the non-colorectal sample is a sample of extra-intestinal tissue which is an adenocarcinoma of unconfirmed origin. In some preferred embodiments, the non-colorectal sample is a blood sample.

As used herein, "an individual suffering from an adenocarcinoma of unconfirmed origin" is meant to refer to an individual who has a tumor in which the origin has not been definitively identified.

As used herein, "an individual is suspected of being susceptible to stomach or esophageal cancer" is meant to refer to an individual who is at a particular risk of developing stomach or esophageal cancer. Examples of individuals at a particular risk of developing stomach or esophageal cancer are those whose family medical history indicates above average incidence of stomach or esophageal cancer among family members and/or those who have already developed stomach or esophageal cancer and have been effectively treated who therefore face a risk of relapse and recurrence.

As used herein, the term "antisense composition" and "antisense molecules" are used interchangeably and are meant to refer to compounds that regulate transcription or translation by hybridizing to DNA or RNA and inhibiting and/or preventing transcription or translation from taking place. Antisense molecules include nucleic acid molecules and derivatives and analogs thereof. Antisense molecules hybridize to DNA or RNA in the same manner as complementary nucleotide sequences do regardless of whether or not the antisense molecule is a nucleic acid molecule or a derivative or analog. Antisense molecules inhibit or prevent transcription or translation of genes whose expression is linked to colorectal cancer.

As used herein, the term "CRCA-1 immunogen" is meant to refer to one or more CRCA-1 translation products or a fragment thereof or a protein that comprises the same or a haptenized product thereof, cells and particles which display at least one CRCA-

1 epitope, and haptenized cells and haptenized particles which display at least one CRCA-1 epitope.

As used herein, the term "recombinant expression vector" is meant to refer to a plasmid, phage, viral particle or other vector which, when introduced into an appropriate host, contains the necessary genetic elements to direct expression of the coding sequence that encodes the protein. The coding sequence is operably linked to the necessary regulatory sequences. Expression vectors are well known and readily available. Examples of expression vectors include plasmids, phages, viral vectors and other nucleic acid molecules or nucleic acid molecule containing vehicles useful to transform host cells and facilitate expression of coding sequences.

As used herein, the term "illegitimate transcription" is meant to refer to the low level or background expression of tissue-specific genes in cells from other tissues. The phenomenon of illegitimate transcription thus provides copies of mRNA for a tissue specific transcript in other tissues. If detection techniques used to detect gene expression are sufficiently sensitive to detect illegitimate transcription, the expression level of the transcript in negative samples due to illegitimate transcription must be discounted using controls and/or quantitative assays and/or other means to eliminate the incidence of false positive due to illegitimate transcription. Alternatively, detection of evidence of CRCA gene expression in sample is achieved without detecting CRCA transcript present due to illegitimate transcription. This is accomplished using techniques which are not sufficiently sensitive to detect the CRCA transcript present due to illegitimate transcription which is present as background.

ST Receptors and CRCA-1

Carcinomas derived from the stomach or esophagus express ST receptors on their cell surfaces. The expression of ST receptors by such tumors enables this protein and its mRNA to be a specific biomarker for the presence of cancer cells in extra-intestinal tissues and blood. Indeed, this characteristic permits the detection of ST receptor mRNA by RT-PCR analysis to be a diagnostic test to stage patients with colorectal cancer and follow patients after surgery for evidence of recurrent disease in their blood as well as to detect stomach and esophageal cancers. Further, the ST receptor may be targeted with a

ligand conjugated to an active agent in order to deliver the active agent to tumor cells *in vivo*.

U.S. Patent No. 5,518,888 issued May 21, 1996 to Waldman, PCT application PCT/US94/12232 filed October 26, 1994, U.S. Application Serial No. 08/467,920 filed June 6, 1995, and U.S. Application Serial No. 08/583,447 filed January 5, 1996, which are each incorporated herein by reference, disclose that metastasized colorectal tumors can be targeted for delivery of active compounds by targeting ST receptors. The presence of ST receptors on cells outside of the intestinal tract as a marker for colorectal cancer allows for the screening, identification and treatment of individuals with metastasized colorectal tumors. ST receptors may also be used to target delivery of gene therapeutics and antisense compounds to colorectal cells.

U.S. Patent No. 5,601,990 issued February 11, 1997 to Waldman, PCT application PCT/US94/12232 filed October 26, 1994, and PCT application PCT/US97/07467 filed May 2, 1997, which are each incorporated herein by reference, disclose that detection of evidence of expression of ST receptors in samples of tissue and body fluid from outside the intestinal tract indicate metastasized colorectal cancer.

PCT application PCT/US97/07565 filed May 2, 1997, which is incorporated herein by reference, disclose that immunogens with epitopes that can be targeted by antibodies that react with ST receptors can be used in vaccines compositions useful as prophylactic and therapeutic anti-metastatic colorectal cancer compositions.

Recently, studies have identified an alternative form of the mRNA for the ST receptor, isolated from human colon carcinoma cells. This mRNA has a substantial deletion of nucleic acids in the first exon in the coding region of the ST receptor. This deletion results in a frameshift of the coding region such that it no longer encodes the amino acid sequence of the ST receptor. However, this alternative splice variant mRNA appears to exhibit a selective pattern of expression that parallels that of the ST receptor. This newly-identified mRNA has been detected only in normal intestinal mucosal cells, human colorectal tumors, but not in extra-intestinal tissues. Furthermore, the expression of this newly-identified mRNA can be detected by RT-PCR analysis separately from ST receptor mRNA. It has now been discovered that CRCA is expressed in cancer cells for stomach and esophageal cancer Thus, the present invention provides the use of this

colorectal cancer-associated transcript (CRCA-1) as a specific molecular diagnostic marker for the diagnosis, staging, and post-operative surveillance of patients with stomach and esophageal cancer.

Detection of the expression of CRCA-1 employing molecular techniques, including, but not limited to, RT-PCR, can be employed to diagnose and stage patients, follow the development of recurrence after surgery, and, potentially, screen normal people for the development of stomach or esophageal cancer. Detection of the expression of CRCA-1 employing molecular techniques, including, but not limited to, RT-PCR, can be employed to diagnose and stage patients, follow the development of recurrence after surgery, and, potentially, screen normal people for the development of stomach or esophageal cancer.

The nucleotide sequence of the CRCA-1 transcription product is set forth as SEQ ID NO:1.

It has further been discovered that one or more translation products may be produced from translation of the CRCA-1 transcription product. The transcription product contains a number of initiation codons from which translation can begin, generating a number of translation products. Amino acid sequences of CRCA-1 translation products are set forth as SEQ ID Nos:2-81.

ST receptors are unique in that they are only localized in the apical brush border membranes of the cells lining the intestinal tract. Indeed, they are not found in any other cell type in placental mammals. In addition, ST receptors are almost exclusively localized to the apical membranes, with little being found in the basolateral membranes on the sides of intestinal cells. Like ST receptors, the expression of CRCA-1 is similarly localized.

Mucosal cells lining the intestine are joined together by tight junctions which form a barrier against the passage of intestinal contents into the blood stream and components of the blood stream into the intestinal lumen. Therefore, the apical location of cells expressing ST receptors and CRCA-1 isolates results in the isolation of such cells from the circulatory system so that they may be considered to exist separate from the rest of the body; essentially the "outside" of the body. Therefore, the rest of the body is considered "outside" the intestinal tract. Compositions administered "outside" the

intestinal tract are maintained apart and segregated from the only cells which normally express ST receptors. Conversely, tissue samples taken from tissue outside of the intestinal tract do not normally contain cells which express ST receptors and CRCA-1.

In individuals suffering from colorectal cancer, the cancer cells are often derived from cells that produce and display the ST receptor and these cancer cells continue to produce and display the ST receptor on their cell surfaces. It has been observed that CRCA-1 is expressed by colorectal cancer cells. Likewise, CRCA-1 is expressed by stomach and esophageal cancer cells.

The expression of CRCA-1 by stomach and esophageal tumor cells provides a detectable target for *in vitro* screening, monitoring and staging as well as a target for *in vivo* delivery of conjugated compositions that comprise active agents for the imaging and treatment.

***In vitro* Diagnostics**

According to some embodiments of the invention, compositions, kits and *in vitro* methods are provided for screening, diagnosing and analyzing patients and patient samples to detect evidence of CRCA-1 expression by cells outside of the intestinal tract wherein the expression of CRCA-1 is suggestive of stomach or esophageal cancer. Furthermore, the present invention relates to methods, compositions and kits useful in the *in vitro* screening, and analysis of patient and patient samples to detect evidence of CRCA-1 expression by tumor cells outside of the intestinal tract wherein the presence of cells that express CRCA-1 suggests or confirms that a tumor is of stomach or esophageal cancer origin. In an additional aspect of the invention, compositions, kits and methods are provided which are useful to visualize stomach or esophageal cells. Such compositions, kits and methods of analyzing tissue samples from the stomach or esophagus tissue to identify primary cancer of the stomach or esophagus.

In vitro screening and diagnostic compositions, methods and kits can be used in the monitoring of individuals who are in high risk groups for stomach or esophageal cancer such as those who have been diagnosed with localized disease and/or metastasized disease and/or those who are genetically linked to the disease. *In vitro* screening and diagnostic compositions, methods and kits can be used in the monitoring of individuals

who are undergoing and/or have been treated for primary stomach or esophageal cancer to determine if the cancer has metastasized. *In vitro* screening and diagnostic compositions, methods and kits can be used in the monitoring of individuals who are undergoing and/or have been treated for stomach or esophageal cancer to determine if the cancer has been eliminated. *In vitro* screening and diagnostic compositions, methods and kits can be used in the monitoring of individuals who are otherwise susceptible, i.e. individuals who have been identified as genetically predisposed such as by genetic screening and/or family histories. Advancements in the understanding of genetics and developments in technology as well as epidemiology allow for the determination of probability and risk assessment an individual has for developing stomach or esophageal cancer. Using family health histories and/or genetic screening, it is possible to estimate the probability that a particular individual has for developing certain types of cancer including stomach or esophageal cancer. Those individuals that have been identified as being predisposed to developing a particular form of cancer can be monitored or screened to detect evidence of stomach or esophageal cancer. Upon discovery of such evidence, early treatment can be undertaken to combat the disease. Accordingly, individuals who are at risk for developing stomach or esophageal cancer may be identified and samples may be isolated form such individuals. The invention is particularly useful for monitoring individuals who have been identified as having family medical histories which include relatives who have suffered from stomach or esophageal cancer. Likewise, the invention is particularly useful to monitor individuals who have been diagnosed as having stomach or esophageal cancer and, particularly those who have been treated and had tumors removed and/or are otherwise experiencing remission including those who have been treated for stomach or esophageal cancer.

In vitro screening and diagnostic compositions, methods and kits can be used in the analysis of tumors. Expression of CRCA-1 is a marker for cell type and suggests the origin of adenocarcinoma of unconfirmed origin may be stomach or esophageal tumors as well as assisting in an initial diagnosis of stomach or esophageal cancer to be confirmed. Tumors believed to be stomach or esophageal in origin can be confirmed as such using the compositions, methods and kits of the invention.

In vitro screening and diagnostic compositions, kits and methods of the invention can be used to analyze tissue samples from the stomach or esophageal tissue to identify primary stomach or esophageal cancer.

According to the invention, compounds are provided which bind to CRCA-1 transcript or translation products. Normal tissue in the body does not have CRCA-1 transcript or translation products except cells of the intestinal tract. The expression of CRCA-1 is a marker for cell type and is useful in the identification of stomach or esophageal cancer in extra-intestinal samples.

In some embodiments of the invention, non-colorectal tissue and fluid samples or tumor samples may be screened to identify the presence or absence of CRCA-1 translation products. Techniques such as ELISA assays and Western blots may be performed to determine whether one or more CRCA-1 translation products are present in a sample.

In some embodiments of the invention, non-colorectal tissue and fluid samples or tumor samples may be screened to identify whether one or more CRCA-1 translation products are being expressed in cells outside of the colorectal tract by detecting the presence or absence of CRCA-1 transcript. The presence of CRCA-1 transcript or cDNA generated therefrom can be determined using techniques such as PCR amplification, branched oligonucleotide technology, Northern Blots (mRNA), Southern Blots (cDNA), or oligonucleotide hybridization.

In some embodiments of the invention, cells of non-colorectal tissue samples or tumor samples may be examined to identify the presence or absence of one or more CRCA-1 translation products. Techniques such as immunohistochemistry blots may be performed on tissue sections to determine whether one or more CRCA-1 translation products are present in a sample.

In some embodiments of the invention, cells of non-colorectal tissue samples or tumor samples may be examined to determine whether one or more CRCA-1 translation products is being expressed in cells outside of the colorectal tract by detecting the presence or absence of the CRCA-1 transcript. The presence of the CRCA-1 transcript or cDNA generated therefrom in cells from tissue sections can be determined using techniques such as *in situ* hybridization.

The presence of one or more CRCA-1 translation products in non-colorectal tissue and fluid samples or on cells from non-colorectal tissue samples suggests possible stomach or esophageal cancer. The presence of one or more CRCA-1 translation products in a tumor sample or on tumor cells suggests that the tumor may be stomach or esophageal in origin. The presence of the CRCA-1 transcript in non-colorectal tissue and fluid samples or in cells from non-colorectal tissue samples suggests possible stomach or esophageal cancer. The presence of the CRCA-1 transcript in tumor samples and tumor cells suggests that the tumor may be stomach or esophageal in origin.

Samples may be obtained from resected tissue or biopsy material including needle biopsy. Tissue section preparation for surgical pathology may be frozen and prepared using standard techniques. Immunohistochemistry and *in situ* hybridization binding assays on tissue sections are performed in fixed cells. Extra-intestinal samples may be homogenized by standard techniques such as sonication, mechanical disruption or chemical lysis such as detergent lysis. It is also contemplated that tumor samples in body such as blood, urine, lymph fluid, cerebral spinal fluid, amniotic fluid, vaginal fluid, semen and stool samples may also be screened to determine if such tumors are colorectal in origin.

Non-colorectal tissue samples may be obtained from any tissue except those of the colorectal tract, i.e. the intestinal tract below the small intestine (i.e. the large intestine (colon), including the cecum, ascending colon, transverse colon, descending colon, and sigmoid colon, and rectum) and additionally the duodenum and small intestine (jejunum and ileum). The cells of all tissue except those of the colorectal tract do not express one or more CRCA-1 translation products. Thus if one or more CRCA-1 translation products or the CRCA-1 transcript are detected in non-colorectal samples, the possible presence of stomach or esophageal cancer cells is suggested. In some preferred embodiments, the tissue samples are lymph nodes.

Tissue samples may be obtained by standard surgical techniques including use of biopsy needles. One skilled in the art would readily appreciate the variety of test samples that may be examined for one or more CRCA-1 translation products and recognize methods of obtaining tissue samples.

Tissue samples may be homogenized or otherwise prepared for screening for the presence of one or more CRCA-1 translation products by well known techniques such as sonication, mechanical disruption, chemical lysis such as detergent lysis or combinations thereof.

Examples of body fluid samples include blood, urine, lymph fluid, cerebral spinal fluid, amniotic fluid, vaginal fluid and semen. In some preferred embodiments, blood is used as a sample of body fluid. Cells may be isolated from fluid sample such as centrifugation. One skilled in the art would readily appreciate the variety of test samples that may be examined for one or more CRCA-1 translation products. Test samples may be obtained by such methods as withdrawing fluid with a syringe or by a swab. One skilled in the art would readily recognize other methods of obtaining test samples.

In an assay using a blood sample, the blood plasma may be separated from the blood cells. The blood plasma may be screened for one or more CRCA-1 translation products including truncated proteins which are released into the blood when one or more CRCA-1 translation products are cleaved from or sloughed off from tumor cells. In some embodiments, blood cell fractions are screened for the presence of stomach or esophageal tumor cells. In some embodiments, lymphocytes present in the blood cell fraction are screened by lysing the cells and detecting the presence of one or more CRCA-1 translation products or the CRCA-1 transcript which may be present as a result of the presence of any stomach or esophageal tumor cells that may have been engulfed by the blood cell.

Aspects of the present invention include various methods of determining whether a sample contains cells that express CRCA-1 by nucleotide sequence-based molecular analysis to detect the CRCA-1 transcript. Several different methods are available for doing so including those using Polymerase Chain Reaction (PCR) technology, branched oligonucleotide technology, Northern blot technology, oligonucleotide hybridization technology, and *in situ* hybridization technology.

The invention relates to oligonucleotide probes and primers used in the methods of identifying the CRCA-1 transcript and to diagnostic kits which comprise such components.

The mRNA sequence-based methods for detect the CRCA-1 transcript include but are not limited to polymerase chain reaction technology, branched

oligonucleotide technology, Northern and Southern blot technology, *in situ* hybridization technology and oligonucleotide hybridization technology.

The methods described herein are meant to exemplify how the present invention may be practiced and are not meant to limit the scope of invention. It is contemplated that other sequence-based methodology for detecting the presence of the CRCA-1 transcript in non-colorectal samples may be employed according to the invention.

A preferred method to detecting the CRCA-1 transcript in genetic material derived from non-colorectal samples uses polymerase chain reaction (PCR) technology. PCR technology is practiced routinely by those having ordinary skill in the art and its uses in diagnostics are well known and accepted. Methods for practicing PCR technology are disclosed in "PCR Protocols: A Guide to Methods and Applications", Innis, M.A., *et al.* Eds. Academic Press, Inc. San Diego, CA (1990) which is incorporated herein by reference. Applications of PCR technology are disclosed in "Polymerase Chain Reaction" Erlich, H.A., *et al.*, Eds. Cold Spring Harbor Press, Cold Spring Harbor, NY (1989) which is incorporated herein by reference. U.S. Patent Number 4,683,202, U.S. Patent Number 4,683,195, U.S. Patent Number 4,965,188 and U.S. Patent Numbers 5,075,216, which are each incorporated herein by reference describe methods of performing PCR. PCR may be routinely practiced using Perkin Elmer Cetus GENE AMP RNA PCR kit, Part No. N808-0017.

PCR technology allows for the rapid generation of multiple copies of DNA sequences by providing 5' and 3' primers that hybridize to sequences present in an RNA or DNA molecule, and further providing free nucleotides and an enzyme which fills in the complementary bases to the nucleotide sequence between the primers with the free nucleotides to produce a complementary strand of DNA. The enzyme will fill in the complementary sequences adjacent to the primers. If both the 5' primer and 3' primer hybridize to nucleotide sequences on the same small fragment of nucleic acid, exponential amplification of a specific double-stranded size product results. If only a single primer hybridizes to the nucleic acid fragment, linear amplification produces single-stranded products of variable length.

PCR primers can be designed routinely by those having ordinary skill in the art using sequence information. The nucleotide sequence of the CRCA-1 transcript is set

forth in SEQ ID NO:1. To perform this method, RNA is extracted from cells in a sample and tested or used to make cDNA using well known methods and readily available starting materials. Those having ordinary skill in the art can readily prepare PCR primers. A set of primers generally contains two primers. When performing PCR on extracted mRNA or cDNA generated therefrom, if the CRCA-1 transcript or cDNA generated therefrom is present, multiple copies of the mRNA or cDNA will be made. If it is not present, PCR will not generate a discrete detectable product. Primers are generally 8-50 nucleotides, preferably about 15-35 nucleotides, more preferably 18-28 nucleotides, which are identical or complementary to and therefor hybridize to the CRCA-1 transcript or cDNA generated therefrom. In preferred embodiments, the primers are each 15-35 nucleotide, more preferably 18-28 nucleotide fragments of SEQ ID NO:1. The primer must hybridize to the sequence to be amplified. Typical primers are 18-28 nucleotides in length and are generally have 50% to 60% G+C composition. The entire primer is preferably complementary to the sequence it must hybridize to. Preferably, primers generate PCR products 100 base pairs to 2000 base pairs. However, it is possible to generate products of 50 to up to 10 kb and more. If mRNA is used as a template, the primers must hybridize to mRNA sequences. If cDNA is used as a template, the primers must hybridize to cDNA sequences. At least one primer hybridizes to a unique nucleotide sequence not found on mRNA that encodes ST receptor protein.

The mRNA or cDNA is combined with the primers, free nucleotides and enzyme following standard PCR protocols. The mixture undergoes a series of temperature changes. If the CRCA-1 transcript or cDNA generated therefrom is present, that is, if both primers hybridize to sequences on the same molecule, the molecule comprising the primers and the intervening complementary sequences will be exponentially amplified. The amplified DNA can be easily detected by a variety of well known means. If no CRCA-1 transcript or cDNA generated therefrom is present, no PCR product will be exponentially amplified. The PCR technology therefore provides an extremely easy, straightforward and reliable method of detecting the CRCA-1 transcript in a sample.

PCR product may be detected by several well known means. The preferred method for detecting the presence of amplified DNA is to separate the PCR reaction material by gel electrophoresis and stain the gel with ethidium bromide in order to visual

the amplified DNA if present. A size standard of the expected size of the amplified DNA is preferably run on the gel as a control.

In some instances, such as when unusually small amounts of RNA are recovered and only small amounts of cDNA are generated therefrom, it is desirable or necessary to perform a PCR reaction on the first PCR reaction product. That is, if difficult to detect quantities of amplified DNA are produced by the first reaction, a second PCR can be performed to make multiple copies of DNA sequences of the first amplified DNA. A nested set of primers are used in the second PCR reaction. The nested set of primers hybridize to sequences downstream of the 5' primer and upstream of the 3' primer used in the first reaction.

The present invention includes oligonucleotide which are useful as primers for performing PCR methods to amplify the CRCA-1 transcript or cDNA generated therefrom.

According to the invention, diagnostic kits can be assembled which are useful to practice methods of detecting the presence of the CRCA-1 transcript or cDNA generated therefrom in non-colorectal samples. Such diagnostic kits comprise oligonucleotide which are useful as primers for performing PCR methods. It is preferred that diagnostic kits according to the present invention comprise a container comprising a size marker to be run as a standard on a gel used to detect the presence of amplified DNA. The size marker is the same size as the DNA generated by the primers in the presence of the CRCA-1 transcript or cDNA generated therefrom. Additional components in some kits include instructions for carrying out the assay. Additionally the kit may optionally comprise depictions or photographs that represent the appearance of positive and negative results.

PCR assays are useful for detecting the CRCA-1 transcript in homogenized tissue samples and cells in body fluid samples. It is contemplated that PCR on the plasma portion of a fluid sample could be used to detect the CRCA-1 transcript.

Another method of determining whether a sample contains cells expressing CRCA-1 is by branched chain oligonucleotide hybridization analysis of mRNA extracted from a sample. Branched chain oligonucleotide hybridization may be performed as described in U.S. Patent Number 5,597,909, U.S. Patent Number 5,437,977 and U.S.

Patent Number 5,430,138, which are each incorporated herein by reference. Reagents may be designed following the teachings of those patents and that sequence of the CRCA-1 transcript.

Another method of determining whether a sample contains cells expressing CRCA-1 is by Northern Blot analysis of mRNA extracted from a non-colorectal sample. The techniques for performing Northern blot analyses are well known by those having ordinary skill in the art and are described in Sambrook, J. *et al.*, (1989) *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY. mRNA extraction, electrophoretic separation of the mRNA, blotting, probe preparation and hybridization are all well known techniques that can be routinely performed using readily available starting material.

The mRNA is extracted using poly dT columns and the material is separated by electrophoresis and, for example, transferred to nitrocellulose paper. Labeled probes made from an isolated specific fragment or fragments can be used to visualize the presence of a complementary fragment fixed to the paper. Probes useful to identify mRNA in a Northern Blot have a nucleotide sequence that is complementary to the CRCA-1 transcript. Those having ordinary skill in the art could use the sequence information in SEQ ID NO:1 to design such probes or to isolate and clone the CRCA-1 transcript or cDNA generated therefrom to be used as a probe. Such probes are at least 15 nucleotides, preferably 30-200, more preferably 40-100 nucleotide fragments and may be the entire CRCA-1 transcript.

According to the invention, diagnostic kits can be assembled which are useful to practice methods of detecting the presence of the CRCA-1 transcript in non-colorectal samples by Northern blot analysis. Such diagnostic kits comprise oligonucleotide which are useful as probes for hybridizing to the mRNA. The probes may be radiolabeled. It is preferred that diagnostic kits according to the present invention comprise a container comprising a size marker to be run as a standard on a gel. It is preferred that diagnostic kits according to the present invention comprise a container comprising a positive control which will hybridize to the probe. Additional components in some kits include instructions for carrying out the assay. Additionally the kit may

optionally comprise depictions or photographs that represent the appearance of positive and negative results.

Northern blot analysis is useful for detecting the CRCA-1 transcript in homogenized tissue samples and cells in body fluid samples. It is contemplated that PCR on the plasma portion of a fluid sample could be used to detect the CRCA-1 transcript.

Another method of detecting the presence of the CRCA-1 transcript by oligonucleotide hybridization technology. Oligonucleotide hybridization technology is well known to those having ordinary skill in the art. Briefly, detectable probes which contain a specific nucleotide sequence that will hybridize to nucleotide sequence of the CRCA-1 transcript. RNA or cDNA made from RNA from a sample is fixed, usually to filter paper or the like. The probes are added and maintained under conditions that permit hybridization only if the probes fully complement the fixed genetic material. The conditions are sufficiently stringent to wash off probes in which only a portion of the probe hybridizes to the fixed material. Detection of the probe on the washed filter indicate complementary sequences.

Probes useful in oligonucleotide assays at least 18 nucleotides of complementary DNA and may be as large as a complete complementary sequence to the CRCA-1 transcript. In some preferred embodiments the probes of the invention are 30-200 nucleotides, preferably 40-100 nucleotides. The probes preferably contain a sequence that is unique with respect to the sequence that encodes the ST receptor.

One having ordinary skill in the art, using the sequence information disclosed in SEQ ID NO:1 can design probes which are fully complementary to the CRCA-1 transcript but not the sequence that encodes ST receptor. Hybridization conditions can be routinely optimized to minimize background signal by non-fully complementary hybridization. In some preferred embodiments, the probes are full length clones. Probes are at least 15 nucleotides, preferably 30-200, more preferably 40-100 nucleotide fragments and may be the entire CRCA-1 transcript.

The present invention includes labeled oligonucleotide which are useful as probes for performing oligonucleotide hybridization. That is, they are fully complementary with the CRCA-1 transcript but not the ST receptor transcript. For example, the mRNA sequence includes portions encoded by different exons. The labeled

probes of the present invention are labeled with radiolabeled nucleotides or are otherwise detectable by readily available nonradioactive detection systems.

According to the invention, diagnostic kits can be assembled which are useful to practice oligonucleotide hybridization methods of the invention. Such diagnostic kits comprise a labeled oligonucleotide which encodes portions of the CRCA-1 transcript different from coding sequences that encode ST receptor. It is preferred that labeled probes of the oligonucleotide diagnostic kits according to the present invention are labeled with a radionucleotide. The oligonucleotide hybridization-based diagnostic kits according to the invention preferably comprise DNA samples that represent positive and negative controls. A positive control DNA sample is one that comprises a nucleic acid molecule which has a nucleotide sequence that is fully complementary to the probes of the kit such that the probes will hybridize to the molecule under assay conditions. A negative control DNA sample is one that comprises at least one nucleic acid molecule, the nucleotide sequence of which is partially complementary to the sequences of the probe of the kit. Under assay conditions, the probe will not hybridize to the negative control DNA sample. Additional components in some kits include instructions for carrying out the assay. Additionally the kit may optionally comprise depictions or photographs that represent the appearance of positive and negative results.

Oligonucleotide hybridization techniques are useful for detecting the CRCA-1 transcript in homogenized tissue samples and cells in body fluid samples. It is contemplated that PCR on the plasma portion of a fluid sample could be used to detect the CRCA-1 transcript.

The present invention relates to *in vitro* kits for evaluating samples of tumors to determine whether or not they are stomach or esophageal in origin and to reagents and compositions useful to practice the same. In some embodiments of the invention, tumor samples may be isolated from individuals undergoing or recovery from surgery to remove tumors in the stomach or esophagus, tumors in other organs or biopsy material. The tumor sample is analyzed to identify the presence or absence of the CRCA-1 transcript. Techniques such as immunohistochemistry assays may be performed to determine whether one or more CRCA-1 translation products are present in cells in the tumor sample which are indicative of colorectal origin. The presence of mRNA that encodes the ST receptor

protein or cDNA generated therefrom can be determined using techniques such as *in situ* hybridization, immunohistochemistry and *in situ* ST binding assay.

In situ hybridization technology is well known by those having ordinary skill in the art. Briefly, cells are fixed and detectable probes which contain a specific nucleotide sequence are added to the fixed cells. If the cells contain complementary nucleotide sequences, the probes, which can be detected, will hybridize to them.

Probes useful in oligonucleotide assays at least 18 nucleotides of complementary DNA and may be as large as a complete complementary sequence to the CRCA-1 transcript. In some preferred embodiments the probes of the invention are 30-200 nucleotides, preferably 40-100 nucleotides. The probes contain a sequence that is unique from those that encode the ST receptor.

One having ordinary skill in the art, using the sequence information set forth in SEQ ID NO:1 and the known sequence for human ST receptor mRNA can design probes useful in *in situ* hybridization technology to identify cells that express CRCA-1. Probes preferably hybridizes to a nucleotide sequence that corresponds to the CRCA-1 transcript. Hybridization conditions can be routinely optimized to minimize background signal by non-fully complementary hybridization and cross hybridization to sequences encoding ST receptors. Probes preferably hybridize to the full length CRCA-1 transcript. Probes are at least 15 nucleotides, preferably 30-200, more preferably 40-100 nucleotide fragments and may be the CRCA transcript, more preferably 18-28 nucleotide fragments of the CRCA-1 transcript.

The probes are fully complementary and do not hybridize well to partially complementary sequences. For *in situ* hybridization according to the invention, it is preferred that the probes are detectable by fluorescence. A common procedure is to label probe with biotin-modified nucleotide and then detect with fluorescently tagged avidin. Hence, probe does not itself have to be labeled with florescent but can be subsequently detected with florescent marker.

The present invention includes labeled oligonucleotide which are useful as probes for performing oligonucleotide hybridization. That is, they are fully complementary with mRNA sequences but not genomic sequences or ST receptor mRNA. For example, the mRNA sequence includes portions encoded by different exons. The

labeled probes of the present invention are labeled with radiolabeled nucleotides or are otherwise detectable by readily available nonradioactive detection systems.

The present invention relates to probes useful for *in situ* hybridization to identify cells that express CRCA-1.

Cells are fixed and the probes are added to the genetic material. Probes will hybridize to the complementary nucleic acid sequences present in the sample. Using a fluorescent microscope, the probes can be visualized by their fluorescent markers.

According to the invention, diagnostic kits can be assembled which are useful to practice *in situ* hybridization methods of the invention are fully complementary with mRNA sequences but not genomic sequences. For example, the mRNA sequence includes different exon sequences. It is preferred that labeled probes of the *in situ* diagnostic kits according to the present invention are labeled with a fluorescent marker.

Those having ordinary skill in the art can analyze the fixed cells to characterize the level of metastatic migration of the colon cancer cells. The labeling of colon-derived cells allows for improved analysis.

Immunohistochemistry techniques may be used to identify and essentially stain cells with one or more CRCA-1 translation products. Such "staining" allows for analysis of metastatic migration. Anti-CRCA-1 translation product antibodies such as those described above of contacted with fixed cells and the CRCA-1 translation products present in the cells reacts with the antibodies. The antibodies are detectably labeled or detected using labeled second antibody or protein A to stain the cells.

The techniques described herein for evaluating tumor sections can also be used to analyze tissue sections for samples of lymph nodes as well as other tissues to identify the presence of cells that express CRCA-1. The samples can be prepared and "stained" to detect expression of CRCA-1.

Immunoassay methods may be used in the diagnosis of individuals suffering from stomach or esophageal cancer by detecting presence of one or more CRCA-1 translation products in sample of non-colorectal tissue or body fluid using antibodies which were produced in response to exposure to such CRCA-1 translation product. Moreover, immunoassay methods may be used to identify individuals suffering from stomach or esophageal cancer by detecting presence of one or more CRCA-1 translation products in

sample of tumor using antibodies which were produced in response to exposure to such CRCA-1 translation product.

The antibodies are preferably monoclonal antibodies. The antibodies are preferably raised against one or more CRCA-1 translation products made in human cells. Immunoassays are well known and there design may be routinely undertaken by those having ordinary skill in the art. Those having ordinary skill in the art can produce monoclonal antibodies which specifically bind to one of the several CRCA-1 translation products and are useful in methods and kits of the invention using standard techniques and readily available starting materials. The techniques for producing monoclonal antibodies are outlined in Harlow, E. and D. Lane, (1988) *ANTIBODIES: A Laboratory Manual*, Cold Spring Harbor Laboratory, Cold Spring Harbor NY, which is incorporated herein by reference, provide detailed guidance for the production of hybridomas and monoclonal antibodies which specifically bind to target proteins. It is within the scope of the present invention to include FAbs and F(Ab)2s which specifically bind to one or more CRCA-1 translation products in place of antibodies.

Briefly, a CRCA-1 translation product is injected into mice. The spleen of the mouse is removed, the spleen cells are isolated and fused with immortalized mouse cells. The hybrid cells, or hybridomas, are cultured and those cells which secrete antibodies are selected. The antibodies are analyzed and, if found to specifically bind to the CRCA-1 translation product, the hybridoma which produces them is cultured to produce a continuous supply of anti-CRCA-1 translation product specific antibodies.

The antibodies are preferably monoclonal antibodies. The antibodies are preferably raised against CRCA-1 translation product made in human cells.

The means to detect the presence of a protein in a test sample are routine and one having ordinary skill in the art can detect the presence or absence of a protein or an antibody using well known methods. One well known method of detecting the presence of a protein is an immunoassay. One having ordinary skill in the art can readily appreciate the multitude of ways to practice an immunoassay to detect the presence of a CRCA-1 translation product in a sample.

According to some embodiments, immunoassays comprise allowing proteins in the sample to bind a solid phase support such as a plastic surface. Detectable antibodies

are then added which selectively binding to either the CRCA-1 translation product. Detection of the detectable antibody indicates the presence of CRCA-1 translation product. The detectable antibody may be a labeled or an unlabeled antibody. Unlabeled antibody may be detected using a second, labeled antibody that specifically binds to the first antibody or a second, unlabeled antibody which can be detected using labeled protein A, a protein that complexes with antibodies. Various immunoassay procedures are described in *Immunoassays for the 80's*, A. Voller et al., Eds., University Park, 1981, which is incorporated herein by reference.

Simple immunoassays may be performed in which a solid phase support is contacted with the test sample. Any proteins present in the test sample bind the solid phase support and can be detected by a specific, detectable antibody preparation. Such a technique is the essence of the dot blot, Western blot and other such similar assays.

Other immunoassays may be more complicated but actually provide excellent results. Typical and preferred immunometric assays include "forward" assays for the detection of a protein in which a first anti-protein antibody bound to a solid phase support is contacted with the test sample. After a suitable incubation period, the solid phase support is washed to remove unbound protein. A second, distinct anti-protein antibody is then added which is specific for a portion of the specific protein not recognized by the first antibody. The second antibody is preferably detectable. After a second incubation period to permit the detectable antibody to complex with the specific protein bound to the solid phase support through the first antibody, the solid phase support is washed a second time to remove the unbound detectable antibody. Alternatively, the second antibody may not be detectable. In this case, a third detectable antibody, which binds the second antibody is added to the system. This type of "forward sandwich" assay may be a simple yes/no assay to determine whether binding has occurred or may be made quantitative by comparing the amount of detectable antibody with that obtained in a control. Such "two-site" or "sandwich" assays are described by Wide, *Radioimmune Assay Method*, Kirkham, Ed., E. & S. Livingstone, Edinburgh, 1970, pp. 199-206, which is incorporated herein by reference.

Other types of immunometric assays are the so-called "simultaneous" and "reverse" assays. A simultaneous assay involves a single incubation step wherein the first

antibody bound to the solid phase support, the second, detectable antibody and the test sample are added at the same time. After the incubation is completed, the solid phase support is washed to remove unbound proteins. The presence of detectable antibody associated with the solid support is then determined as it would be in a conventional "forward sandwich" assay. The simultaneous assay may also be adapted in a similar manner for the detection of antibodies in a test sample.

The "reverse" assay comprises the stepwise addition of a solution of detectable antibody to the test sample followed by an incubation period and the addition of antibody bound to a solid phase support after an additional incubation period. The solid phase support is washed in conventional fashion to remove unbound protein/antibody complexes and unreacted detectable antibody. The determination of detectable antibody associated with the solid phase support is then determined as in the "simultaneous" and "forward" assays. The reverse assay may also be adapted in a similar manner for the detection of antibodies in a test sample.

The first component of the immunometric assay may be added to nitrocellulose or other solid phase support which is capable of immobilizing proteins. The first component for determining the presence of CRCA-1 translation product in a test sample is an anti-CRCA-1 translation product antibody. By "solid phase support" or "support" is intended any material capable of binding proteins. Well-known solid phase supports include glass, polystyrene, polypropylene, polyethylene, dextran, nylon, amylases, natural and modified celluloses, polyacrylamides, agaroses, and magnetite. The nature of the support can be either soluble to some extent or insoluble for the purposes of the present invention. The support configuration may be spherical, as in a bead, or cylindrical, as in the inside surface of a test tube or the external surface of a rod. Alternatively, the surface may be flat such as a sheet, test strip, etc. Those skilled in the art will know many other suitable "solid phase supports" for binding proteins or will be able to ascertain the same by use of routine experimentation. A preferred solid phase support is a 96-well microtiter plate.

To detect the presence of one or more CRCA-1 translation products, detectable anti-CRCA-1 translation product antibodies are used. Several methods are well known for the detection of antibodies.

One method in which the antibodies can be detectably labeled is by linking the antibodies to an enzyme and subsequently using the antibodies in an enzyme immunoassay (EIA) or enzyme-linked immunosorbent assay (ELISA), such as a capture ELISA. The enzyme, when subsequently exposed to its substrate, reacts with the substrate and generates a chemical moiety which can be detected, for example, by spectrophotometric, fluorometric or visual means. Enzymes which can be used to detectably label antibodies include, but are not limited to malate dehydrogenase, staphylococcal nuclease, delta-5-steroid isomerase, yeast alcohol dehydrogenase, alpha-glycerophosphate dehydrogenase, triose phosphate isomerase, horseradish peroxidase, alkaline phosphatase, asparaginase, glucose oxidase, beta-galactosidase, ribonuclease, urease, catalase, glucose-6-phosphate dehydrogenase, glucoamylase and acetylcholinesterase. One skilled in the art would readily recognize other enzymes which may also be used.

Another method in which antibodies can be detectably labeled is through radioactive isotopes and subsequent use in a radioimmunoassay (RIA) (see, for example, Work, T.S. *et al.*, *Laboratory Techniques and Biochemistry in Molecular Biology*, North Holland Publishing Company, N.Y., 1978, which is incorporated herein by reference). The radioactive isotope can be detected by such means as the use of a gamma counter or a scintillation counter or by autoradiography. Isotopes which are particularly useful for the purpose of the present invention are ^{3}H, ^{125}I, ^{131}I, ^{35}S, and ^{14}C. Preferably ^{125}I is the isotope. One skilled in the art would readily recognize other radioisotopes which may also be used.

It is also possible to label the antibody with a fluorescent compound. When the fluorescent-labeled antibody is exposed to light of the proper wave length, its presence can be detected due to its fluorescence. Among the most commonly used fluorescent labeling compounds are fluorescein isothiocyanate, rhodamine, phycoerythrin, phycocyanin, allophycocyanin, o-phthaldehyde and fluorescamine. One skilled in the art would readily recognize other fluorescent compounds which may also be used.

Antibodies can also be detectably labeled using fluorescence-emitting metals such as ^{152}Eu, or others of the lanthanide series. These metals can be attached to the protein-specific antibody using such metal chelating groups as diethylenetriaminepentaacetic acid (DTPA) or ethylenediamine-tetraacetic acid (EDTA).

One skilled in the art would readily recognize other fluorescence-emitting metals as well as other metal chelating groups which may also be used.

Antibody can also be detectably labeled by coupling to a chemiluminescent compound. The presence of the chemiluminescent-labeled antibody is determined by detecting the presence of luminescence that arises during the course of a chemical reaction. Examples of particularly useful chemoluminescent labeling compounds are luminol, isoluminol, theromatic acridinium ester, imidazole, acridinium salt and oxalate ester. One skilled in the art would readily recognize other chemiluminescent compounds which may also be used.

Likewise, a bioluminescent compound may be used to label antibodies. Bioluminescence is a type of chemiluminescence found in biological systems in which a catalytic protein increases the efficiency of the chemiluminescent reaction. The presence of a bioluminescent protein is determined by detecting the presence of luminescence. Important bioluminescent compounds for purposes of labeling are luciferin, luciferase and aequorin. One skilled in the art would readily recognize other bioluminescent compounds which may also be used.

Detection of the protein-specific antibody, fragment or derivative may be accomplished by a scintillation counter if, for example, the detectable label is a radioactive gamma emitter. Alternatively, detection may be accomplished by a fluorometer if, for example, the label is a fluorescent material. In the case of an enzyme label, the detection can be accomplished by colorometric methods which employ a substrate for the enzyme. Detection may also be accomplished by visual comparison of the extent of enzymatic reaction of a substrate in comparison with similarly prepared standards. One skilled in the art would readily recognize other appropriate methods of detection which may also be used.

The binding activity of a given lot of antibodies may be determined according to well known methods. Those skilled in the art will be able to determine operative and optimal assay conditions for each determination by employing routine experimentation.

Positive and negative controls may be performed in which known amounts of one or more CRCA-1 translation products and no CRCA-1 translation product,

respectively, are added to assays being performed in parallel with the test assay. One skilled in the art would have the necessary knowledge to perform the appropriate controls. In addition, the kit may comprise instructions for performing the assay. Additionally the kit may optionally comprise depictions or photographs that represent the appearance of positive and negative results.

CRCA-1 translation products may be produced as a reagent for positive controls routinely. One skilled in the art would appreciate the different manners in which the CRCA-1 translation products may be produced and isolated.

Antibody composition refers to the antibody or antibodies required for the detection of the protein. For example, the antibody composition used for the detection of a CRCA-1 translation product in a test sample comprises a first antibody that binds to the CRCA-1 translation product as well as a second or third detectable antibody that binds the first or second antibody, respectively.

To examine a test sample for the presence of a CRCA-1 translation product, a standard immunometric assay such as the one described below may be performed. A first anti-CRCA-1 translation product antibody, which recognizes a specific portion of CRCA-1 translation product, is added to a 96-well microtiter plate in a volume of buffer. The plate is incubated for a period of time sufficient for binding to occur and subsequently washed with PBS to remove unbound antibody. The plate is then blocked with a PBS/BSA solution to prevent sample proteins from non-specifically binding the microtiter plate. Test sample are subsequently added to the wells and the plate is incubated for a period of time sufficient for binding to occur. The wells are washed with PBS to remove unbound protein. Labeled anti-CRCA-1 translation product antibodies, which recognize portions of CRCA-1 translation product not recognized by the first antibody, are added to the wells. The plate is incubated for a period of time sufficient for binding to occur and subsequently washed with PBS to remove unbound, labeled anti-CRCA-1 translation product antibody. The amount of labeled and bound anti-CRCA-1 translation product antibody is subsequently determined by standard techniques.

Kits which are useful for the detection of a CRCA-1 translation product in a test sample comprise a container comprising anti-CRCA-1 translation product antibodies and a container or containers comprising controls. Controls include one control sample

which does not contain CRCA-1 translation product and/or another control sample which contained the CRCA-1 translation product. The anti-CRCA-1 translation product antibodies used in the kit are detectable such as being detectably labeled. If the detectable anti-CRCA-1 translation product antibody is not labeled, it may be detected by second antibodies or protein A for example which may also be provided in some kits in separate containers. Additional components in some kits include solid support, buffer, and instructions for carrying out the assay. Additionally the kit may optionally comprise depictions or photographs that represent the appearance of positive and negative results.

The immunoassay is useful for detecting one or more CRCA-1 translation products in homogenized tissue samples and body fluid samples including the plasma portion or cells in the fluid sample.

Western Blots may be useful in assisting the diagnosis os individuals suffering from stomach or esophageal cancer by detecting presence of one or more CRCA-1 translation products of non-colorectal tissue or body fluid. Western blots may also be used to detect presence of one or more CRCA-1 translation products in sample of tumor from an individual suffering from cancer. Western blots use detectable anti-CRCA-1 translation product antibodies to bind to any CRCA-1 translation product present in a sample and thus indicate the presence of the receptor in the sample.

Western blot techniques, which are described in Sambrook, J. *et al.*, (1989) *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, which is incorporated herein by reference, are similar to immunoassays with the essential difference being that prior to exposing the sample to the antibodies, the proteins in the samples are separated by gel electrophoresis and the separated proteins are then probed with antibodies. In some preferred embodiments, the matrix is an SDS-PAGE gel matrix and the separated proteins in the matrix are transferred to a carrier such as filter paper prior to probing with antibodies. Anti-CRCA-1 translation product antibodies described above are useful in Western blot methods.

Generally, samples are homogenized and cells are lysed using detergent such as Triton-X. The material is then separated by the standard techniques in Sambrook, J. *et al.*, (1989) *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY.

Kits which are useful for the detection of one or more CRCA-1 translation products in a test sample by Western Blot comprise a container comprising anti-CRCA-1 translation products antibodies and a container or containers comprising controls. Controls include one control sample which does not contain CRCA-1 translation product and/or another control sample which contained one or more CRCA-1 translation products. The anti-CRCA-1 translation product antibodies used in the kit are detectable such as being detectably labeled. If the detectable anti-CRCA-1 translation product antibody is not labeled, it may be detected by second antibodies or protein A for example which may also be provided in some kits in separate containers. Additional components in some kits include instructions for carrying out the assay. Additionally the kit may optionally comprise depictions or photographs that represent the appearance of positive and negative results.

Western blots are useful for detecting one or more CRCA-1 translation products in homogenized tissue samples and body fluid samples including the plasma portion or cells in the fluid sample.

***In vivo* Imaging and Therapeutics**

According to some embodiments of the invention, compositions and *in vivo* methods are provided for detecting, imaging, or treating stomach or esophageal tumors in an individual.

When the conjugated compositions of the present invention are administered outside the intestinal tract such as when administered in the circulatory system, they remain segregated from the cells that line the intestinal tract and will bind only to cells outside the intestinal tract which express CRCA-1. The conjugated compositions will not bind to non-colorectal derived cells. Thus, the active moieties of conjugated compositions administered outside the intestinal tract are delivered to cells which express CRCA-1 such as stomach or esophageal cancer cells.

Therapeutic and diagnostic pharmaceutical compositions useful in the present invention include conjugated compounds that specifically target cells that express CRCA-1. These conjugated compounds include moieties that bind to one or more CRCA-1 translation products which do not bind to cells of normal tissue in the body except cells

of the intestinal tract since the cells of other tissues do not possess such translation products. Further, according to the invention, the CRCA-1 translation product binding moieties do not bind to ST receptors.

Unlike normal colorectal cells, cancer cells that express CRCA-1 are accessible to substances administered outside the intestinal tract, for example administered in the circulatory system. The only CRCA-1 translation products in normal tissue exist in the apical membranes of intestinal mucosa cells and thus effectively isolated from the targeted cancer chemotherapeutics and imaging agents administered outside the intestinal tract by the intestinal mucosa barrier. Thus, stomach or esophageal cancer cells may be targeted by conjugated compounds of the present invention by introducing such compounds outside the intestinal tract such as for example by administering pharmaceutical compositions that comprise conjugated compounds into the circulatory system.

One having ordinary skill in the art can identify individuals suspected of suffering from stomach or esophageal. In those individuals diagnosed with stomach or esophageal cancer, it is standard therapy to suspect metastasis and aggressively attempt to eradicate metastasized cells. The present invention provides pharmaceutical compositions and methods for imaging and thereby will more definitively diagnose metastasis. Further, the present invention provides pharmaceutical compositions comprising therapeutic agents and methods for specifically targeting and eliminating stomach or esophageal cancer cells. Further, the present invention provides pharmaceutical compositions that comprise therapeutics and methods for specifically eliminating stomach or esophageal cancer cells.

The pharmaceutical compositions which comprise conjugated compositions of the present invention may be used to diagnose or treat individuals suffering from primary and metastatic stomach or esophageal tumors.

The present invention relies upon the use of a CRCA-1 translation product binding moiety in a conjugated composition. The CRCA-1 translation product binding moiety is essentially a portion of the conjugated composition which acts as a ligand to a CRCA-1 translation product and thus specifically binds to it. The conjugated composition also includes an active moiety which is associated with the CRCA-1 translation product

binding moiety; the active moiety being an active agent which is either useful to image, target, neutralize or kill the cell.

According to the present invention, the CRCA-1 translation product binding moiety is the CRCA-1 translation product ligand portion of a conjugated composition. In some embodiments, the CRCA-1 translation product ligand is an antibody.

In some preferred embodiments, conjugated compounds comprise CRCA-1 translation product binding moieties that comprise an anti-CRCA-1 translation product antibody.

It is preferred that the CRCA-1 translation product ligand used as the CRCA-1 translation product binding moiety be as small as possible. Thus it is preferred that the CRCA-1 translation product ligand be a non-peptide small molecule or small peptide, preferably less than 25 amino acids, more preferably less than 20 amino acids. In some embodiments, the CRCA-1 translation product ligand which constitute the CRCA-1 translation product binding moiety of a conjugated composition is less than 15 amino acids. CRCA-1 translation product binding peptide comprising less than 10 amino acids and CRCA-1 translation product binding peptide less than 5 amino acids may be used as CRCA-1 translation product binding moieties according to the present invention. It is within the scope of the present invention to include larger molecules which serve as CRCA-1 translation product binding moieties including, but not limited to molecules such as antibodies which specifically bind to CRCA-1 translation product.

CRCA-1 translation product ligands useful as CRCA-1 translation product binding moieties may be identified using various well known combinatorial library screening technologies such as those set forth in Example 1 herein.

An assay may be used to test both peptide and non-peptide compositions to determine whether or not they are CRCA-1 translation product ligands or, to test conjugated compositions to determine if they possess CRCA-1 translation product binding activity. Such compositions that specifically bind to CRCA-1 translation product can be identified by a competitive binding assay using antibodies known to bind to the CRCA-1 translation product. The competitive binding assay is a standard technique in pharmacology which can be readily performed by those having ordinary skill in the art using readily available starting materials.

CRCA-1 translation products may be produced synthetically, recombinantly or isolated from natural sources.

Using a solid phase synthesis as an example, the protected or derivatized amino acid is attached to an inert solid support through its unprotected carboxyl or amino group. The protecting group of the amino or carboxyl group is then selectively removed and the next amino acid in the sequence having the complementary (amino or carboxyl) group suitably protected is admixed and reacted with the residue already attached to the solid support. The protecting group of the amino or carboxyl group is then removed from this newly added amino acid residue, and the next amino acid (suitably protected) is then added, and so forth. After all the desired amino acids have been linked in the proper sequence, any remaining terminal and side group protecting groups (and solid support) are removed sequentially or concurrently, to provide the final peptide. The peptide of the invention are preferably devoid of benzylated or methylbenzylated amino acids. Such protecting group moieties may be used in the course of synthesis, but they are removed before the peptides are used. Additional reactions may be necessary, as described elsewhere, to form intramolecular linkages to restrain conformation.

CRCA-1 translation products and conjugated compositions or portions thereof which are peptides may also be prepared by recombinant DNA techniques. Provision of a suitable DNA sequence encoding the desired peptide permits the production of the peptide using recombinant techniques now known in the art. The coding sequence can be obtained from natural sources or synthesized or otherwise constructed using widely available starting materials by routine methods. When the coding DNA is prepared synthetically, advantage can be taken of known codon preferences of the intended host where the DNA is to be expressed.

To produce a CRCA-1 translation product which occurs in nature, one having ordinary skill in the art can, using well-known techniques, obtain a DNA molecule encoding the CRCA-1 translation product and insert that DNA molecule into a commercially available expression vector for use in well-known expression systems such as for example those described herein.

For example, the commercially available plasmid pSE420 (Invitrogen, San Diego, CA) may be used for recombinant production in *E. coli*. The commercially

available plasmid pYES2 (Invitrogen, San Diego, CA) may be used for production in *S. cerevisiae* strains of yeast. The commercially available MaxBac™ (Invitrogen, San Diego, CA) complete baculovirus expression system may be used for production in insect cells. The commercially available plasmid pcDNA I (Invitrogen, San Diego, CA) may be used for production in mammalian cells such as Chinese Hamster Ovary cells.

One having ordinary skill in the art may use these or other commercially available expression vectors and systems or produce vectors using well-known methods and readily available starting materials. Expression systems containing the requisite control sequences, such as promoters and polyadenylation signals, and preferably enhancers, are readily available and known in the art for a variety of hosts. *See e.g.*, Sambrook et al., *Molecular Cloning a Laboratory Manual*, Second Ed. Cold Spring Harbor Press (1989). Thus, the desired proteins can be prepared in both prokaryotic and eukaryotic systems, resulting in a spectrum of processed forms of the protein.

The most commonly used prokaryotic system remains *E. coli*, although other systems such as *B. subtilis* and *Pseudomonas* are also useful. Suitable control sequences for prokaryotic systems include both constitutive and inducible promoters including the *lac* promoter, the *trp* promoter, hybrid promoters such as tac promoter, the *lambda* phage Pl promoter. In general, foreign proteins may be produced in these hosts either as fusion or mature proteins. When the desired sequences are produced as mature proteins, the sequence produced may be preceded by a methionine which is not necessarily efficiently removed. Accordingly, the peptides and proteins claimed herein may be preceded by an N-terminal Met when produced in bacteria. Moreover, constructs may be made wherein the coding sequence for the peptide is preceded by an operable signal peptide which results in the secretion of the protein. When produced in prokaryotic hosts in this matter, the signal sequence is removed upon secretion.

A wide variety of eukaryotic hosts are also now available for production of recombinant foreign proteins. As in bacteria, eukaryotic hosts may be transformed with expression systems which produce the desired protein directly, but more commonly signal sequences are provided to effect the secretion of the protein. Eukaryotic systems have the additional advantage that they are able to process introns which may occur in the genomic sequences encoding proteins of higher organisms. Eukaryotic systems also provide a

variety of processing mechanisms which result in, for example, glycosylation, carboxy-terminal amidation, oxidation or derivatization of certain amino acid residues, conformational control, and so forth.

Commonly used eukaryotic systems include, but are not limited to, yeast, fungal cells, insect cells, mammalian cells, avian cells, and cells of higher plants. Suitable promoters are available which are compatible and operable for use in each of these host types as well as are termination sequences and enhancers, as e.g. the baculovirus polyhedron promoter. As above, promoters can be either constitutive or inducible. For example, in mammalian systems, the mouse metallothionene promoter can be induced by the addition of heavy metal ions.

The particulars for the construction of expression systems suitable for desired hosts are known to those in the art. For recombinant production of the protein, the DNA encoding it is suitably ligated into the expression vector of choice and then used to transform the compatible host which is then cultured and maintained under conditions wherein expression of the foreign gene takes place. The protein of the present invention thus produced is recovered from the culture, either by lysing the cells or from the culture medium as appropriate and known to those in the art.

One having ordinary skill in the art can, using well-known techniques, isolate the protein that is produced.

According to the present invention, the active moiety may be a therapeutic agent or an imaging agent. One having ordinary skill in the art can readily recognize the advantages of being able to specifically target metastasized colorectal cells with an CRCA-1 translation product ligand and conjugate such a ligand with many different active agents.

Chemotherapeutics useful as active moieties which when conjugated to a CRCA-1 translation product binding moiety are specifically delivered to cells that express CRCA-1 such as stomach or esophageal cancer cells, are typically small chemical entities produced by chemical synthesis. Chemotherapeutics include cytotoxic and cytostatic drugs. Chemotherapeutics may include those which have other effects on cells such as reversal of the transformed state to a differentiated state or those which inhibit cell replication. Examples of chemotherapeutics include common cytotoxic or cytostatic drugs such as for example: methotrexate (amethopterin), doxorubicin (adrimycin), daunorubicin,

cytosinarabinoside, etoposide, 5-4 fluorouracil, melphalan, chlorambucil, and other nitrogen mustards (e.g. cyclophosphamide), *cis*-platinum, vindesine (and other vinca alkaloids), mitomycin and bleomycin. Other chemotherapeutics include: purothionin (barley flour oligopeptide), macromomycin. 1,4-benzoquinone derivatives and trenimon.

Toxins are useful as active moieties. When a toxin is conjugated to a CRCA-1 translation product binding moiety, the conjugated composition is specifically delivered to a cell that expresses CRCA-1 such as stomach or esophageal cancer cells by way of the CRCA-1 translation product binding moiety and the toxin moiety kills the cell. Toxins are generally complex toxic products of various organisms including bacteria, plants, *etc.* Examples of toxins include but are not limited to: ricin, ricin A chain (ricin toxin), *Pseudomonas* exotoxin (PE), diphtheria toxin (DT), *Clostridium perfringens* phospholipase C (PLC), bovine pancreatic ribonuclease (BPR), pokeweed antiviral protein (PAP), abrin, abrin A chain (abrin toxin), cobra venom factor (CVF), gelonin (GEL), saporin (SAP), modeccin, viscumin and volkensin. As discussed above, when protein toxins are employed with CRCA-1 translation product binding peptides, conjugated compositions may be produced using recombinant DNA techniques. Briefly, a recombinant DNA molecule can be constructed which encodes both the CRCA-1 translation product ligand and the toxin on a chimeric gene. When the chimeric gene is expressed, a fusion protein is produced which includes a CRCA-1 translation product binding moiety and an active moiety. Protein toxins are also useful to form conjugated compounds with CRCA-1 translation product binding peptides through non-peptidyl bonds.

In addition, there are other approaches for utilizing active agents for the treatment of cancer. For example, conjugated compositions may be produced which include a CRCA-1 translation product binding moiety and an active moiety which is an active enzyme. The CRCA-1 translation product binding moiety specifically localizes the conjugated composition to the tumor cells. An inactive prodrug which can be converted by the enzyme into an active drug is administered to the patient. The prodrug is only converted to an active drug by the enzyme which is localized to the tumor. An example of an enzyme/prodrug pair includes alkaline phosphatase/ etoposidephosphate. In such a case, the alkaline phosphatase is conjugated to a CRCA-1 translation product binding

ligand. The conjugated compound is administered and localizes at the metastasized cell. Upon contact with etoposidephosphate (the prodrug), the etoposidephosphate is converted to etoposide, a chemotherapeutic drug which is taken up by the cancer cell.

Radiosensitizing agents are substances that increase the sensitivity of cells to radiation. Examples of radiosensitizing agents include nitroimidazoles, metronidazole and misonidazole (see: DeVita, V.T. Jr. in *Harrison's Principles of Internal Medicine*, p.68, McGraw-Hill Book Co., N.Y. 1983, which is incorporated herein by reference). The conjugated compound that comprises a radiosensitizing agent as the active moiety is administered and localizes at the metastasized cell. Upon exposure of the individual to radiation, the radiosensitizing agent is "excited" and causes the death of the cell.

Radionuclides may be used in pharmaceutical compositions that are useful for radiotherapy or imaging procedures.

Examples of radionuclides useful as toxins in radiation therapy include: ^{47}Sc, ^{67}Cu, ^{90}Y, ^{109}Pd, ^{123}I, ^{125}I, ^{131}I, ^{186}Re, ^{188}Re, ^{199}Au, ^{211}At, ^{212}Pb and ^{212}B. Other radionuclides which have been used by those having ordinary skill in the art include: ^{32}P and ^{33}P, ^{71}Ge, ^{77}As, ^{103}Pb, ^{105}Rh, ^{111}Ag, ^{119}Sb, ^{121}Sn, ^{131}Cs, ^{143}Pr, ^{161}Tb, ^{177}Lu, ^{191}Os, ^{193M}Pt, ^{197}Hg, all beta negative and/or auger emitters. Some preferred radionuclides include: ^{90}Y, ^{131}I ^{211}At and $^{212}Pb/^{212}Bi$.

According to the present invention, the active moieties may be an imaging agent. Imaging agents are useful diagnostic procedures as well as the procedures used to identify the location of metastasized cells. Imaging can be performed by many procedures well-known to those having ordinary skill in the art and the appropriate imaging agent useful in such procedures may be conjugated to a CRCA-1 translation product ligand by well-known means. Imaging can be performed, for example, by radioscintigraphy, nuclear magnetic resonance imaging (MRI) or computed tomography (CT scan). The most commonly employed radionuclide imaging agents include radioactive iodine and indium. Imaging by CT scan may employ a heavy metal such as iron chelates. MRI scanning may employ chelates of gadolinium or manganese. Additionally, positron emission tomography (PET) may be possible using positron emitters of oxygen, nitrogen, iron, carbon, or gallium. Example of radionuclides useful in imaging procedures include: ^{43}K, ^{52}Fe, ^{57}Co,

^{67}Cu, ^{67}Ga, ^{68}Ga, ^{77}Br, $^{81}Rb/^{81M}Kr$, ^{87M}Sr, ^{99M}Tc, ^{111}In, ^{113M}In, ^{123}I, ^{125}I, ^{127}Cs, ^{129}Cs, ^{131}I, ^{132}I, ^{197}Hg, ^{203}Pb and ^{206}Bi.

It is preferred that the conjugated compositions be non-immunogenic or immunogenic at a very low level. Accordingly, it is preferred that the CRCA-1 translation product binding moiety be a small, poorly immunogenic or non-immunogenic peptide or a non-peptide. Alternatively, the CRCA-1 translation product binding moiety may be a humanized or primatized antibody or a human antibody.

CRCA-1 translation product ligands are conjugated to active agents by a variety of well-known techniques readily performed without undue experimentation by those having ordinary skill in the art. The technique used to conjugate the CRCA-1 translation product ligand to the active agent is dependent upon the molecular nature of the CRCA-1 translation product ligand and the active agent. After the CRCA-1 translation product ligand and the active agent are conjugated to form a single molecule, assays may be performed to ensure that the conjugated molecule retains the activities of the moieties. The competitive binding assay described above may be used to confirm that the CRCA-1 translation product binding moiety retains its binding activity as a conjugated compound. Similarly, the activity of the active moiety may be tested using various assays for each respective type of active agent. Radionuclides retain there activity, i.e. their radioactivity, irrespective of conjugation. With respect to active agents which are toxins, drugs and targeting agents, standard assays to demonstrate the activity of unconjugated forms of these compounds may be used to confirm that the activity has been retained.

Conjugation may be accomplished directly between the CRCA-1 translation product ligand and the active agent or linking, intermediate molecular groups may be provided between the CRCA-1 translation product ligand and the active agent. Crosslinkers are particularly useful to facilitate conjugation by providing attachment sites for each moiety. Crosslinkers may include additional molecular groups which serve as spacers to separate the moieties from each other to prevent either from interfering with the activity of the other.

One having ordinary skill in the art may conjugate a CRCA-1 translation product ligand to a chemotherapeutic drug using well-known techniques. For example, Magerstadt, M. *Antibody Conjugates and Malignant Disease.* (1991) CRC Press, Boca

Raton, USA, pp. 110-152) which is incorporated herein by reference, teaches the conjugation of various cytostatic drugs to amino acids of antibodies. Such reactions may be applied to conjugate chemotherapeutic drugs to CRCA-1 translation product ligands, including anti-CRCA-1 translation product antibodies, with an appropriate linker. Most of the chemotherapeutic agents currently in use in treating cancer possess functional groups that are amenable to chemical crosslinking directly with proteins. For example, free amino groups are available on methotrexate, doxorubicin, daunorubicin, cytosinarabinoside, *cis*-platin, vindesine, mitomycin and bleomycin while free carboxylic acid groups are available on methotrexate, melphalan, and chlorambucil. These functional groups, that is free amino and carboxylic acids, are targets for a variety of homobifunctional and heterobifunctional chemical crosslinking agents which can crosslink these drugs directly to the single free amino group of an antibody. For example, one procedure for crosslinking CRCA-1 translation product ligands which have a free amino group to active agents which have a free amino group such as methotrexate, doxorubicin, daunorubicin, cytosinarabinoside, *cis*-platin, vindesine, mitomycin and bleomycin, or alkaline phosphatase, or protein- or peptide-based toxin employs homobifunctional succinimidyl esters, preferably with carbon chain spacers such as disuccinimidyl suberate (Pierce Co, Rockford, IL). In the event that a cleavable conjugated compound is required, the same protocol would be employed utilizing 3,3'- dithiobis (sulfosuccinimidylpropionate; Pierce Co.).

In order to conjugate a CRCA-1 translation product ligand that is a peptide or protein to a peptide-based active agent such as a toxin, the CRCA-1 translation product ligand and the toxin may be produced as a single, fusion protein either by standard peptide synthesis or recombinant DNA technology, both of which can be routinely performed by those having ordinary skill in the art. Alternatively, two peptides, the CRCA-1 translation product ligand peptide and the peptide-based toxin may be produced and/or isolated as separate peptides and conjugated using crosslinkers. As with conjugated compositions that contain chemotherapeutic drugs, conjugation of CRCA-1 translation product binding peptides and toxins can exploit the ability to modify the single free amino group of a CRCA-1 translation product binding peptide while preserving the receptor-binding function of this molecule.

One having ordinary skill in the art may conjugate a CRCA-1 translation product ligand to a radionuclide using well-known techniques. For example, Magerstadt, M. (1991) *Antibody Conjugates And Malignant Disease,* CRC Press, Boca Raton, FLA,; and Barchel, S.W. and Rhodes, B.H., (1983) *Radioimaging and Radiotherapy,* Elsevier, NY, NY, each of which is incorporated herein by reference, teach the conjugation of various therapeutic and diagnostic radionuclides to amino acids of antibodies.

The present invention provides pharmaceutical compositions that comprise the conjugated compounds of the invention and pharmaceutically acceptable carriers or diluents. The pharmaceutical composition of the present invention may be formulated by one having ordinary skill in the art. Suitable pharmaceutical carriers are described in *Remington's Pharmaceutical Sciences*, A. Osol, a standard reference text in this field, which is incorporated herein by reference. In carrying out methods of the present invention, conjugated compounds of the present invention can be used alone or in combination with other diagnostic, therapeutic or additional agents. Such additional agents include excipients such as coloring, stabilizing agents, osmotic agents and antibacterial agents. Pharmaceutical compositions are preferably sterile and pyrogen free.

The conjugated compositions of the invention can be, for example, formulated as a solution, suspension or emulsion in association with a pharmaceutically acceptable parenteral vehicle. Examples of such vehicles are water, saline, Ringer's solution, dextrose solution, and 5% human serum albumin. Liposomes may also be used. The vehicle may contain additives that maintain isotonicity (e.g., sodium chloride, mannitol) and chemical stability (e.g., buffers and preservatives). The formulation is sterilized by commonly used techniques. For example, a parenteral composition suitable for administration by injection is prepared by dissolving 1.5% by weight of active ingredient in 0.9% sodium chloride solution.

The pharmaceutical compositions according to the present invention may be administered as either a single dose or in multiple doses. The pharmaceutical compositions of the present invention may be administered either as individual therapeutic agents or in combination with other therapeutic agents. The treatments of the present invention may be combined with conventional therapies, which may be administered sequentially or simultaneously.

The pharmaceutical compositions of the present invention may be administered by any means that enables the conjugated composition to reach the targeted cells. In some embodiments, routes of administration include those selected from the group consisting of intravenous, intraarterial, intraperitoneal, local administration into the blood supply of the organ in which the tumor resides or directly into the tumor itself. Intravenous administration is the preferred mode of administration. It may be accomplished with the aid of an infusion pump.

The dosage administered varies depending upon factors such as: the nature of the active moiety; the nature of the conjugated composition; pharmacodynamic characteristics; its mode and route of administration; age, health, and weight of the recipient; nature and extent of symptoms; kind of concurrent treatment; and frequency of treatment.

Because conjugated compounds are specifically targeted to cells with one or more CRCA-1 translation products, conjugated compounds which comprise chemotherapeutics or toxins are administered in doses less than those which are used when the chemotherapeutics or toxins are administered as unconjugated active agents, preferably in doses that contain up to 100 times less active agent. In some embodiments, conjugated compounds which comprise chemotherapeutics or toxins are administered in doses that contain 10-100 times less active agent as an active moiety than the dosage of chemotherapeutics or toxins administered as unconjugated active agents. To determine the appropriate dose, the amount of compound is preferably measured in moles instead of by weight. In that way, the variable weight of different CRCA-1 translation product binding moieties does not affect the calculation. Presuming a one to one ratio of CRCA-1 translation product binding moiety to active moiety in conjugated compositions of the invention, less moles of conjugated compounds may be administered as compared to the moles of unconjugated compounds administered, preferably up to 100 times less moles.

Typically, chemotherapeutic conjugates are administered intravenously in multiple divided doses.

Up to 20 gm IV/dose of methotrexate is typically administered in an unconjugated form. When methotrexate is administered as the active moiety in a conjugated compound of the invention, there is a 10-to 100-fold dose reduction. Thus,

presuming each conjugated compound includes one molecule of methotrexate conjugated to one CRCA-1 translation product binding moiety, of the total amount of conjugated compound administered, up to about 0.2 - 2.0 g of methotrexate is present and therefore administered. In some embodiments, of the total amount of conjugated compound administered, up to about 200 mg - 2g of methotrexate is present and therefore administered.

To dose conjugated compositions comprising CRCA-1 translation product binding moieties linked to active moieties that are radioisotopes in pharmaceutical compositions useful as imaging agents, it is presumed that each CRCA-1 translation product binding moiety is linked to one radioactive active moiety. The amount of radioisotope to be administered is dependent upon the radioisotope. Those having ordinary skill in the art can readily formulate the amount of conjugated compound to be administered based upon the specific activity and energy of a given radionuclide used as an active moiety. Typically 0.1-100 millicuries per dose of imaging agent, preferably 1-10 millicuries, most often 2-5 millicuries are administered. Thus, pharmaceutical compositions according to the present invention useful as imaging agents which comprise conjugated compositions comprising a CRCA-1 translation product binding moiety and a radioactive moiety comprise 0.1-100 millicuries, in some embodiments preferably 1-10 millicuries, in some embodiments preferably 2-5 millicuries, in some embodiments more preferably 1-5 millicuries. Examples of dosages include: ^{131}I = between about 0.1-100 millicuries per dose, in some embodiments preferably 1-10 millicuries, in some embodiments 2-5 millicuries, and in some embodiments about 4 millicuries; ^{111}In = between about 0.1-100 millicuries per dose, in some embodiments preferably 1-10 millicuries, in some embodiments 1-5 millicuries, and in some embodiments about 2 millicuries; ^{99m}Tc = between about 0.1-100 millicuries per dose, in some embodiments preferably 5-75 millicuries, in some embodiments 10-50 millicuries, and in some embodiments about 27 millicuries. Wessels B.W. and R.D. Rogus (1984) *Med. Phys.* 11:638 and Kwok, C.S. *et al.* (1985) *Med. Phys.* 12:405, both of which are incorporated herein by reference, disclose detailed dose calculations for diagnostic and therapeutic conjugates which may be used in the preparation of pharmaceutical compositions of the present invention which include radioactive conjugated compounds.

One aspect of the present invention relates to a method of treating individuals suspected of suffering from stomach or esophageal cancer. Such individuals may be treated by administering to the individual a pharmaceutical composition that comprises a pharmaceutically acceptable carrier or diluent and a conjugated compound that comprises a CRCA-1 translation product binding moiety and an active moiety wherein the active moiety is a radiostable therapeutic agent. In some embodiments of the present invention, the pharmaceutical composition comprises a pharmaceutically acceptable carrier or diluent and a conjugated compound that comprises a CRCA-1 translation product binding moiety and an active moiety wherein the active moiety is a radiostable active agent and the CRCA-1 translation product binding moiety is an antibody. In some embodiments of the present invention, the pharmaceutical composition comprises a pharmaceutically acceptable carrier or diluent and a conjugated compound that comprises a CRCA-1 translation product binding moiety and an active moiety wherein the active moiety is a radiostable therapeutic agent. In some embodiments of the present invention, the pharmaceutical composition comprises a pharmaceutically acceptable carrier or diluent and a conjugated compound that comprises a CRCA-1 translation product binding moiety and an active moiety wherein the active moiety is a radiostable active agent selected from the group consisting of: methotrexate, doxorubicin, daunorubicin, cytosinarabinoside, etoposide, 5-4 fluorouracil, melphalan, chlorambucil, *cis*-platinum, vindesine, mitomycin, bleomycin, purothionin, macromomycin, 1,4-benzoquinone derivatives, trenimon, ricin, ricin A chain, *Pseudomonas* exotoxin, diphtheria toxin, *Clostridium perfringens* phospholipase C, bovine pancreatic ribonuclease, pokeweed antiviral protein, abrin, abrin A chain, cobra venom factor, gelonin, saporin, modeccin, viscumin, volkensin, alkaline phosphatase, nitroimidazole, metronidazole and misonidazole. The individual being treated may be diagnosed as having metastasized colorectal cancer or may be diagnosed as having localized colorectal cancer and may undergo the treatment proactively in the event that there is some metastasis as yet undetected. The pharmaceutical composition contains a therapeutically effective amount of the conjugated composition. A therapeutically effective amount is an amount which is effective to cause a cytotoxic or cytostatic effect on cancer cells without causing lethal side effects on the individual.

One aspect of the present invention relates to a method of treating individuals suspected of suffering from stomach or esophageal cancer. Such individuals may be treated by administering to the individual a pharmaceutical composition that comprises a pharmaceutically acceptable carrier or diluent and a conjugated compound that comprises a CRCA-1 translation product binding moiety and an active moiety wherein the active moiety is a radioactive. In some embodiments of the present invention, the pharmaceutical composition comprises a pharmaceutically acceptable carrier or diluent and a conjugated compound that comprises a CRCA-1 translation product binding moiety and an active moiety wherein the active moiety is a radioactive and the ST receptor binding moiety is an antibody. In some embodiments of the present invention, the pharmaceutical composition comprises a pharmaceutically acceptable carrier or diluent and a conjugated compound that comprises a CRCA-1 translation product and an active moiety wherein the active moiety is a radioactive agent selected from the group consisting of: ^{47}Sc, ^{67}Cu, ^{90}Y, ^{109}Pd, ^{123}I, ^{125}I, ^{131}I, ^{186}Re, ^{188}Re, ^{199}Au, ^{211}At, ^{212}Pb, ^{212}B, ^{32}P and ^{33}P, ^{71}Ge, ^{77}As, ^{103}Pb, ^{105}Rh, ^{111}Ag, ^{119}Sb, ^{121}Sn, ^{131}Cs, ^{143}Pr, ^{161}Tb, ^{177}Lu, ^{191}Os, ^{193M}Pt, ^{197}Hg, ^{32}P and ^{33}P, ^{71}Ge, ^{77}As, ^{103}Pb, ^{105}Rh, ^{111}Ag, ^{119}Sb, ^{121}Sn, ^{131}Cs, ^{143}Pr, ^{161}Tb, ^{177}Lu, ^{191}Os, ^{193M}Pt, ^{197}Hg, all beta negative and/or auger emitters. The individual being treated may be diagnosed as having metastasized cancer or may be diagnosed as having localized cancer and may undergo the treatment proactively in the event that there is some metastasis as yet undetected. The pharmaceutical composition contains a therapeutically effective amount of the conjugated composition. A therapeutically effective amount is an amount which is effective to cause a cytotoxic or cytostatic effect on metastasized colorectal cancer cells without causing lethal side effects on the individual. The composition may be injected intratumorally into primary tumors.

One aspect of the present invention relates to a method of detecting primary or metastasized stomach or esophageal cancer cells in an individual suspected of suffering from primary or metastasized stomach or esophageal cancer by radioimaging. Individuals may be suspected of having primary stomach or esophageal tumors which diagnosis can be confirmed by administering to the individual, an imaging agent which binds to CRCA-1 translation product. Tumors can be imaged by detecting localization at the stomach or esophagus. Individuals may be diagnosed as suffering from metastasized stomach or

esophageal cancer and the metastasized stomach or esophageal cancer cells may be detected by administering to the individual, preferably by intravenous administration, a pharmaceutical composition that comprises a pharmaceutically acceptable carrier or diluent and a conjugated compound that comprises a CRCA-1 translation product binding moiety and an active moiety wherein the active moiety is a radioactive and detecting the presence of a localized accumulation or aggregation of radioactivity, indicating the presence of cells with a CRCA-1 translation product. In some embodiments of the present invention, the pharmaceutical composition comprises a pharmaceutically acceptable carrier or diluent and a conjugated compound that comprises a CRCA-1 translation product binding moiety and an active moiety wherein the active moiety is a radioactive and the ST receptor binding moiety is an antibody. In some embodiments of the present invention, the pharmaceutical composition comprises a pharmaceutically acceptable carrier or diluent and a conjugated compound that comprises an ST receptor binding moiety and an active moiety wherein the active moiety is a radioactive agent selected from the group consisting of: radioactive heavy metals such as iron chelates, radioactive chelates of gadolinium or manganese, positron emitters of oxygen, nitrogen, iron, carbon, or gallium, ^{43}K, ^{52}Fe, ^{57}Co, ^{67}Cu, ^{67}Ga, ^{68}Ga, ^{77}Br, $^{81}Rb/^{81M}Kr$, ^{87M}Sr, ^{99M}Tc, ^{111}In, ^{113M}In, ^{123}I, ^{125}I, ^{127}Cs, ^{129}Cs, ^{131}I, ^{132}I, ^{197}Hg, ^{203}Pb and ^{206}Bi. The individual being treated may be diagnosed as having metastasizing stomach or esophageal cancer or may be diagnosed as having localized stomach or esophageal cancer and may undergo the treatment proactively in the event that there is some metastasis as yet undetected. The pharmaceutical composition contains a diagnostically effective amount of the conjugated composition. A diagnostically effective amount is an amount which can be detected at a site in the body where cells with ST receptors are located without causing lethal side effects on the individual.

Drug Delivery Targeted To Stomach or Esophageal Cancer Cells Generally

Another aspect of the invention relates to unconjugated and conjugated compositions which comprise a CRCA-1 translation product ligand used to deliver therapeutic agents to cells that comprise a CRCA-1 translation product such as stomach and esophageal cancer cells. In some embodiments, the agent is a drug or toxin such as: methotrexate, doxorubicin, daunorubicin, cytosinarabinoside, etoposide, 5-4 fluorouracil,

melphalan, chlorambucil, *cis*-platinum, vindesine, mitomycin, bleomycin, purothionin, macromomycin, 1,4-benzoquinone derivatives, trenimon, ricin, ricin A chain, *Pseudomonas* exotoxin, diphtheria toxin, *Clostridium perfringens* phospholipase C, bovine pancreatic ribonuclease, pokeweed antiviral protein, abrin, abrin A chain, cobra venom factor, gelonin, saporin, modeccin, viscumin, volkensin, alkaline phosphatase, nitroimidazole, metronidazole and misonidazole.. Genetic material is delivered to cancer cells to produce an antigen that can be targeted by the immune system or to produce a protein which kills the cell or inhibits its proliferation. In some embodiments, the CRCA-1 translation product ligand is used to deliver nucleic acids that encode nucleic acid molecules which replace defective endogenous genes or which encode therapeutic proteins. In some embodiments, the compositions are used in gene therapy protocols to deliver to individuals, genetic material needed and/or desired to make up for a genetic deficiency.

In some embodiments, the CRCA-1 translation product ligand is combined with or incorporated into a delivery vehicle thereby converting the delivery vehicle into a specifically targeted delivery vehicle. For example, a CRCA-1 translation product binding peptide may be integrated into the outer portion of a viral particle making such a virus a CRCA-1 translation product-bearing cell specific virus. Similarly, the coat protein of a virus may be engineered such that it is produced as a fusion protein which includes an active CRCA-1 translation product binding peptide that is exposed or otherwise accessible on the outside of the viral particle making such a virus a CRCA-1 translation product-bearing cell-specific virus. In some embodiments, a CRCA-1 translation product ligand may be integrated or otherwise incorporated into the liposomes wherein the CRCA-1 translation product ligand is exposed or otherwise accessible on the outside of the liposome making such liposomes specifically targeted to CRCA-1 translation product-bearing cells.

The active agent in the conjugated or unconjugated compositions according to this aspect of the invention is a drug, toxin or nucleic acid molecule. The nucleic acid may be RNA or preferably DNA. In some embodiments, the nucleic acid molecule is an antisense molecule or encodes an antisense sequence whose presence in the cell inhibits production of an undesirable protein. In some embodiments, the nucleic acid molecule encodes a ribozyme whose presence in the cell inhibits production of an undesirable protein. In some embodiments, the nucleic acid molecule encodes a protein or peptide that

is desirably produced in the cell. In some embodiments, the nucleic acid molecule encodes a functional copy of a gene that is defective in the targeted cell. The nucleic acid molecule is preferably operably linked to regulatory elements needed to express the coding sequence in the cell.

Liposomes are small vesicles composed of lipids. Genetic constructs which encode proteins that are desired to be expressed in CRCA-1 translation product-bearing cells are introduced into the center of these vesicles. The outer shell of these vesicles comprise an a CRCA-1 translation product ligand. *Liposomes* Volumes 1, 2 and 3 CRC Press Inc. Boca Raton FLA, which is incorporated herein by reference, disclose preparation of liposome-encapsulated active agents which include antibodies in the outer shell. In the present invention, a CRCA-1 translation product ligand such as for example an anti-CRCA-1 translation product antibodies is associated with the in the outer shell. Unconjugated compositions which comprise a CRCA-1 translation product ligand in the matrix of a liposome with an active agent inside include such compositions in which the CRCA-1 translation product ligand is preferably an antibody.

In one embodiment, the delivery of normal copies of the p53 tumor suppressor gene to the cancer cells is accomplished using CRCA-1 translation product ligand to target the gene therapeutic. Mutations of the p53 tumor suppressor gene appears to play a prominent role in the development of many cancers. One approach to combating this disease is the delivery of normal copies of this gene to the cancer cells expressing mutant forms of this gene. Genetic constructs that comprise normal p53 tumor suppressor genes are incorporated into liposomes that comprise a CRCA-1 translation product ligand. The composition is delivered to the tumor. CRCA-1 translation product binding ligands specifically target and direct the liposomes containing the normal gene to correct the lesion created by mutation of p53 suppressor gene. Preparation of genetic constructs is with the skill of those having ordinary skill in the art. The present invention allows such construct to be specifically targeted by using the CRCA-1 translation product ligands of the present invention. The compositions of the invention include a CRCA-1 translation product ligand such as an anti-CRCA-1 translation product antibody associated with a delivery vehicle and a gene construct which comprises a coding sequence for a protein whose production is desired in the cells of the intestinal tract linked to necessary regulatory sequences for

expression in the cells. For uptake by cells of the intestinal tract, the compositions are administered orally or by enema whereby they enter the intestinal tract and contact cells which comprise one or more CRCA-1 translation products. The delivery vehicles associate with the CRCA-1 translation product by virtue of the CRCA-1 translation product ligand and the vehicle is internalized into the cell or the active agent/genetic construct is otherwise taken up by the cell. Once internalized, the construct can provide a therapeutic effect on the individual.

Antisense

The present invention provides compositions, kits and methods which are useful to prevent and treat stomach or esophageal cancer cells by providing the means to specifically deliver antisense compounds to stomach or esophageal cancer cells and thereby stop expression of genes in such cells in which undesirable gene expression is taking place without negatively effecting cells in which no such expression occurs.

The conjugated compositions of the present invention are useful for targeting cells that express CRCA-1 including stomach or esophageal cancer cells. The conjugated compositions will not bind to non-colorectal derived cells. Non-colorectal cells, lacking one or more CRCA-1 translation products, do not take up the conjugated compositions. Thus, the present invention provides compositions and methods of delivering antisense compositions to stomach or esophageal cancer cells only.

The present invention provides a stomach or esophageal cancer specific approach in which only stomach or esophageal cancer cells are exposed to the active portion of the compound and only stomach or esophageal cancer cells are effected by the conjugated compound. The CRCA-1 binding moiety binds to stomach or esophageal cancer cells. Upon binding to these cells, the conjugated compound is internalized and the delivery of the conjugated compound including the antisense portion of the molecule is effected. The presence of the conjugated compound in normal colorectal cells has no effect on such cells because the cancer-associated gene for which the antisense molecule that makes up the active moiety of the conjugated compound is complementary is not being expressed. However, in colorectal cancer cells, the cancer gene for which the antisense molecule that makes up the active moiety of the conjugated compound is complementary is

being expressed. The presence of the conjugated compound in colorectal cancer cells serves to inhibit or prevent transcription or translation of the cancer gene and thereby reduce or eliminate the transformed phenotype.

The invention can be used to combat localized or metastasized stomach or esophageal cancer as well as to prevent the emergence of the transformed phenotype. Thus the invention can be used therapeutically as well as prophylactically.

One having ordinary skill in the art can readily identify individuals suspected of suffering from stomach or esophageal cancer. In those individuals diagnosed with stomach or esophageal cancer, it is standard therapy to suspect metastasis and aggressively attempt to eradicate metastasized cells. The present invention provides pharmaceutical compositions and methods for specifically targeting and eliminating metastasized stomach or esophageal cancer cells. Further, the present invention provides pharmaceutical compositions that comprise therapeutics and methods for specifically eliminating stomach or esophageal cancer cells.

The present invention relies upon the use of a CRCA-1 translation product binding moiety in a conjugated composition. The CRCA-1 translation product binding moiety is essentially a portion of the conjugated composition which acts as a ligand to the CRCA-1 translation product and thus specifically binds to these receptors. The conjugated composition also includes an active moiety which is associated with the CRCA-1 translation product binding moiety; the active moiety being an antisense composition useful to inhibit or prevent transcription or translation of expression of genes whose expression is associated with cancer.

According to the present invention, the active moiety is an antisense composition. In particular, the antisense molecule that makes up the active moiety of a conjugated compound hybridizes to DNA or RNA in a stomach or esophageal cancer cell and inhibits and/or prevents transcription or translation of the DNA or RNA from taking place. The antisense compositions may be a nucleic acid molecule, a derivative or an analogs thereof. The chemical nature of the antisense composition may be that of a nucleic acid molecule or a modified nucleic acid molecule or a non-nucleic acid molecule which possess functional groups that mimic a DNA or RNA molecule that is complementary to the DNA or RNA molecule whose expression is to be inhibited or otherwise prevented.

Antisense compositions inhibit or prevent transcription or translation of genes whose expression is linked to stomach or esophageal cancer, i.e. cancer associated genes.

Point mutations insertions, and deletions in K-ras and H-ras have been identified in many tumors. Complex characteristics of the alterations of oncogenes HER-2/ERBB-2, HER-1/ERBB-1, HRAS-1, C-MYC and anti-oncogenes p53, RB1.

Chemical carcinogenesis in a rat model demonstrated point mutations in fos, an oncogene which mediates transcriptional regulation and proliferation. See: Alexander, RJ, *et al.* Oncogene alterations in rat colon tumors induced by N-methyl-N-nitrosourea. *American Journal of the Medical Sciences.* 303(1):16-24, 1992, Jan. which is hereby incorporated herein by reference including all references cited therein which are also hereby incorporated herein by reference.

Chemical carcinogenesis in a rat model demonstrated point mutations in the oncogene abl. See: Alexander, RJ, *et al.* Oncogene alterations in rat colon tumors induced by N-methyl-N-nitrosourea. *American Journal of the Medical Sciences.* 303(1):16-24, 1992, Jan.

MYC is an oncogene that plays a role in regulating transcription and proliferation. A 15-base antisense oligonucleotide to myc complementary to the translation initiation region of exon II was incubated with colorectal cancer cells. This antisense molecule inhibited proliferation of colorectal cancer cells in a dos-dependent fashion. Interestingly, the uptake of this oligonucleotide was low (0.7%). Also, transfer of a normal chromosome 5 to colorectal cancer cells resulted in the regulation of myc expression and loss of proliferation. These data suggest that a tumor suppressor gene important in the regulation of myc is contained on this chromosome.

A novel protein tyrosine phosphatase, G1, has been identified. Examination of the mRNA encoding this protein in colorectal tumor cells revealed that it undergoes point mutations and deletions in these cells and may play a role in proliferation characteristic of these cells. Takekawa, M. *et al.* Chromosomal localization of the protein tyrosine phosphatase G1 gene and characterization of the aberrant transcripts in human colon cancer cells. *FEBS Letters.* 339(3):222-8, 1994 Feb. 21, which is hereby incorporated herein by reference including all references cited therein which are also hereby incorporated herein by reference.

Gastrin regulates colon cancer cell growth through a cyclic AMP-dependent mechanism mediated by PKA. Antisense oligodeoxynucleotides to the regulatory subunit of a specific class of PKA inhibited the growth-promoting effects of cyclic AMP in colon carcinoma cells. See: Bold, RJ, *et al.* Experimental gene therapy of human colon cancer. *Surgery.* **116**(2):189-95; discussion 195-6, 1994 Aug. and Yokozaki, H., *et al.* An antisense oligodeoxynucleotide that depletes RI alpha subunit of cyclic AMP-dependent protein kinase induces growth inhibition in human cancer cells. *Cancer Research.* **53**(4):868-72, 1993 Feb 15, which are both hereby incorporated herein by reference including all references cited therein which are also hereby incorporated herein by reference.

CRIPTO is an epidermal growth factor-related gene expressed in a majority of colorectal cancer tumors. Antisense phosphorothioate oligodeoxynucleotides to the 5'-end of CRIPTO mRNA significantly reduced CRIPTO expression and inhibited colorectal tumor cell growth *in vitro* and *in vivo*. Ciardiello, F. *et al.* Inhibition of CRIPTO expression and tumorigenicity in human colon cancer cells by antisense RNA and oligodeoxynucleotides. *Oncogene.* **9**(1):291-8, 1994 Jan. which are both hereby incorporated herein by reference including all references cited therein which are also hereby incorporated herein by reference.

Many carcinoma cells secrete transforming growth factor alpha. A 23 nucleotide antisense oligonucleotide to TGF alpha mRNA inhibited both DNA synthesis an proliferation of colorectal cancer cells. Sizeland, AM, Burgess, AW. Antisense transforming growth factor alpha oligonucleotides inhibit autocrine stimulated proliferation of a colon carcinoma cell line. *Molecular Biology of the Cell.* **3**(11):1235-43, 1992 Nov. which is hereby incorporated herein by reference including all references cited therein which are also hereby incorporated herein by reference.

Antisense compositions including oligonucleotides, derivatives and analogs thereof, conjugation protocols, and antisense strategies for inhibition of transcription and translation are generally described in: *Antisense Research and Applications,* Crooke, S. and B. Lebleu, eds. CRC Press, Inc. Boca Raton FLA 1993; *Nucleic Acids in Chemistry and Biology* Blackburn, G. and M.J. Gait, eds. IRL Press at Oxford University Press, Inc. New York 1990; and *Oligonucleotides and Analogues: A Practical Approach* Eckstein, F. ed.,

IRL Press at Oxford University Press, Inc. New York 1991; which are each hereby incorporated herein by reference including all references cited therein which are hereby incorporated herein by reference.

The antisense molecules of the present invention comprise a sequence complementary to a fragment of a colorectal cancer gene. See Ullrich et al., *EMBO J.*, **1986**, *5*:2503, which is hereby incorporated herein by reference.

Antisense compositions which can make up an active moiety in conjugated compounds of the invention include oligonucleotides formed of homopyrimidines can recognize local stretches of homopurines in the DNA double helix and bind to them in the major groove to form a triple helix. See: Helen, C and Toulme, JJ. Specific regulation of gene expression by antisense, sense, and antigene nucleic acids. *Biochem. Biophys Acta*, **1049**:99-125, 1990 which is hereby incorporated herein by reference including all references cited therein which are hereby incorporated herein by reference. Formation of the triple helix would interrupt the ability of the specific gene to undergo transcription by RNA polymerase. Triple helix formation using myc-specific oligonucleotides has been observed. See: Cooney, M, *et al. Science* **241**:456-459 which is hereby incorporated herein by reference including all references cited therein which are hereby incorporated herein by reference.

Antisense oligonucleotides of DNA or RNA complementary to sequences at the boundary between introns and exons can be employed to prevent the maturation of newly-generated nuclear RNA transcripts of specific genes into mRNA for transcription.

Antisense RNA complimentary to specific genes can hybridize with the mRNA for tat gene and prevent its translation. Antisense RNA can be provided to the cell as "ready-to-use" RNA synthesized in vitro or as an antisense gene stably transfected into cells which will yield antisense RNA upon transcription. Hybridization with mRNA results in degradation of the hybridized molecule by RNAse H and/or inhibition of the formation of translation complexes. Both result in a failure to produce the product of the original gene.

Antisense sequences of DNA or RNA can be delivered to cells. Several chemical modifications have been developed to prolong the stability and improve the function of these molecules without interfering in their ability to recognize specific

sequences. These include increasing their resistance to degradation by DNases, including phosphotriesters, methylphosphonates, phosphorothioates, alpha-anomers, increasing their affinity for their s by covalent linkage to various intercalating agents such as psoralens, and increasing uptake by cells by conjugation to various groups including polylysine. These molecules recognize specific sequences encoded in mRNA and their hybridization prevents translation of and increases the degradation of these messages.

Conjugated compositions of the invention provide a specific and effective means for terminating the expression of genes which cause neoplastic transformation. CRCA-1 translation products undergo ligand-induced endocytosis and can deliver conjugated compounds to the cytoplasm of cells.

CRCA-1 translation product binding moieties are conjugated directly to antisense compositions such as nucleic acids which are active in inducing a response. For example, antisense oligonucleotides to MYC are conjugated directly to an anti-CRCA-1 translation product antibody. This has been performed employing peptides that bind to the CD4 receptor. See: Cohen, JS, ed. *Oligodeoxynucleotides: Antisense Inhibitors of Gene Expression. Topics in Molecular and Structural Biology.* CRC Press, Inc., Boca Raton, 1989. which is hereby incorporated herein by reference including all references cited therein which are hereby incorporated herein by reference. The precise backbone and its synthesis is not specified and can be selected from well-established techniques. Synthesis would involve either chemical conjugation or direct synthesis of the chimeric molecule by solid phase synthesis employing FMOC chemistry. See: Haralambidis, J, *et al.* (1987) *Tetrahedron Lett.* **28**:5199-5202, which is hereby incorporated herein by reference including all references cited therein which are hereby incorporated herein by reference. Alternatively, the peptide-nucleic acid conjugate may be synthesized directly by solid phase synthesis as a peptide-peptide nucleic acid chimera by solid phase synthesis. Nielsen, PE, *et al.* (1994) Sequence-specific transcription arrest by peptide nucleic acid bound to the DNA template strand. *Gene* **149**:139-145, which is hereby incorporated herein by reference including all references cited therein which are hereby incorporated herein by reference.

In some embodiments, polylysine can be complexed to conjugated compositions of the invention in a non-covalent fashion to nucleic acids and used to

enhance delivery of these molecules to the cytoplasm of cells. In addition, peptides and proteins can be conjugated to polylysine in a covalent fashion and this conjugate complexed with nucleic acids in a non-covalent fashion to further enhance the specificity and efficiency of uptake of the nucleic acids into cells. Thus, CRCA-1 translation product ligand is conjugated chemically to polylysine by established techniques. The polylysine-CRCA-1 translation product ligand conjugate may be complexed with nucleic acids of choice. Thus, polylysine-orosomucoid conjugates were employed to specifically plasmids containing genes to be expressed to hepatoma cells expressing the orosomucoid receptor. This approach can be used to delivery whole genes, or oligonucleotides. Thus, it has the potential to terminate the expression of an undesired gene (eg. MYC, ras) or replace the function of a lost or deleted gene (eg. hMSH2, hMLH1, hPMS1, and hPMS2).

According to a preferred embodiment, Myc serves as a gene whose expression is inhibited by an antisense molecule within a conjugated composition. CRCA-1 translation product binding moieties are used to deliver a 15-based antisense oligonucleotide to myc complementary to the translation initiation region of exon II. The 15-base antisense oligonucleotide to MYC is synthesized as reported in Collins, JF, Herman, P, Schuch, C, Bagby GC, Jr. *Journal of Clinical Investigation.* **89**(5):1523-7, 1992 May. In some embodiments, the conjugated composition is conjugated to polylysine as reported previously. Wu, GY, and Wu, CH. (1988) Evidence for ed gene delivery to Hep G2 hepatoma cells in vitro. *Biochem.* **27**:887-892 which is incorporated herein by reference.

Conjugated compositions may be synthesized as a chimeric molecule directly by solid phase synthesis. pmolar to nanomolar concentrations for this conjugate suppress MYC synthesis in colorectal cancer cells *in vitro*.

Antisense molecules are preferably hybridize to, i.e. are complementary to, a nucleotide sequence that is 5-50 nucleotides in length, more preferably 5-25 nucleotides and in some embodiments 10-15 nucleotides.

In addition, mismatches within the sequences identified above, which achieve the methods of the invention, such that the mismatched sequences are substantially complementary to the colorectal cancer gene sequences are also considered within the scope of the disclosure. Mismatches which permit substantial complementarity to the

colorectal cancer gene sequences will be known to those of skill in the art once armed with the present disclosure. The oligos may also be unmodified or modified.

Therapeutic compositions and methods may be used to combat stomach or esophageal cancer in cases where the cancer is localized and/or metastasized. Individuals are administered a therapeutically effective amount of conjugated compound. A therapeutically effective amount is an amount which is effective to cause a cytotoxic or cytostatic effect on metastasized colorectal cancer cells without causing lethal side effects on the individual. An individual who has been administered a therapeutically effective amount of a conjugated composition has a increased chance of eliminating stomach or esophageal cancer as compared to the risk had the individual not received the therapeutically effective amount.

To treat localized stomach or esophageal cancer, a therapeutically effective amount of a conjugated compound is administered such that it will come into contact with the localized tumor. Thus, the conjugated compound is administered orally or intratumorally. Oral and rectal formulation are taught in Remington's Pharmaceutical Sciences, 18th Edition, 1990, Mack Publishing Co., Easton PA. which is incorporated herein by reference.

The pharmaceutical compositions according to the present invention may be administered as either a single dose or in multiple doses. The pharmaceutical compositions of the present invention may be administered either as individual therapeutic agents or in combination with other therapeutic agents. The treatments of the present invention may be combined with conventional therapies, which may be administered sequentially or simultaneously.

The present invention is directed to a method of delivering antisense compounds to stomach or esophageal cells and inhibiting expression of cancer genes in mammals. The methods comprise administering to a mammal an effective amount of a conjugated composition which comprises a CRCA-1 translation product binding moiety conjugated to an antisense oligonucleotide having a sequence which is complementary to a region of DNA or mRNA of a cancer gene.

The conjugated compounds may be administering to mammals in a mixture with a pharmaceutically-acceptable carrier, selected with regard to the intended route of

administration and the standard pharmaceutical practice. Dosages will be set with regard to weight, and clinical condition of the patient. The conjugated compositions of the present invention will be administered for a time sufficient for the mammals to be free of undifferentiated cells and/or cells having an abnormal phenotype. In therapeutic methods treatment extends for a time sufficient to inhibit transformed cells from proliferating and conjugated compositions may be administered in conjunction with other chemotherapeutic agents to manage and combat the patient's cancer.

The conjugated compounds of the invention may be employed in the method of the invention singly or in combination with other compounds. The amount to be administered will also depend on such factors as the age, weight, and clinical condition of the patient. See Gennaro, Alfonso, ed., Remington's Pharmaceutical Sciences, 18th Edition, 1990, Mack Publishing Co., Easton PA.

Therapeutic and Prophylactic Vaccines

The invention relates to prophylactic and therapeutic vaccines for protecting individuals against stomach or esophageal cancer and for treating individuals who are suffering from stomach or esophageal cancer.

According to the present invention, one or more of the CRCA-1 translation products serves as a target against which a protective and therapeutic immune response can be induced. Specifically, vaccines are provided which induce an immune response against a CRCA-1 translation product. The vaccines of the invention include, but are not limited to, the following vaccine technologies:

1) DNA vaccines, i.e. vaccines in which DNA that encodes at least an epitope from a CRCA-1 translation product that is not present on ST receptor protein is administered to an individual's cells where the epitope is expressed and serves as a target for an immune response;

2) infectious vector mediated vaccines such as recombinant adenovirus, vaccinia, *Salmonella*, and BCG wherein the vector carries genetic information that encodes at least an epitope from a CRCA-1 translation product that is not present on ST receptor protein such that when the infectious vector is administered to an individual, the epitope is expressed and serves as a target for an immune response;

3) killed or inactivated vaccines which a) comprise either killed cells or inactivated viral particles that display at least an epitope from a CRCA-1 translation product that is not present on ST receptor protein and b) when administered to an individual serves as a target for an immune response;

3) haptenized killed or inactivated vaccines which a) comprise either killed cells or inactivated viral particles that display at least an epitope from a CRCA-1 translation product that is not present on ST receptor protein, b) are haptenized to be more immunogenic and c) when administered to an individual serves as a target for an immune response;

4) subunit vaccines which are vaccines that include protein molecules that include at least an epitope from a CRCA-1 translation product that is not present on ST receptor protein; and

5) haptenized subunit vaccines which are vaccines that a) include protein molecules that include at least an epitope from a CRCA-1 translation product that is not present on ST receptor protein and b) are haptenized to be more immunogenic.

The present invention relates to administering to an individual a protein or nucleic acid molecule that comprises or encodes, respectively, an immunogenic epitope against which an therapeutic and prophylactic immune response can be induced. Such epitopes are generally at least 6-8 amino acids in length. The vaccines of the invention therefore comprise proteins which are at least, or nucleic acids which encode at least, 6-8 amino acids in length from one or more CRCA-1 translation products that is not present on ST receptor protein. The vaccines of the invention may comprise proteins which are at least, or nucleic acids which encode at least 10 to about 1000 amino acids in length. The vaccines of the invention may comprise proteins which are at least, or nucleic acids which encode at least, about 25 to about 500 amino acids in length. The vaccines of the invention may comprise proteins which are at least, or nucleic acids which encode at least, about 50 to about 400 amino acids in length. The vaccines of the invention may comprise proteins which are at least, or nucleic acids which encode at least, about 100 to about 300 amino acids in length.

The present invention relates to compositions for and methods of treating individuals who are known to have stomach or esophageal cancer. Stomach or esophageal

cancer may be diagnosed by those having ordinary skill in the art using art accepted clinical and laboratory pathology protocols. The present invention provides an immunotherapeutic vaccine useful to treat individuals who have been diagnosed as suffering from stomach or esophageal cancer. The immunotherapeutic vaccines of the present invention may be administered in combination with other therapies.

The present invention relates to compositions for and methods of preventing stomach or esophageal cancer in individual is suspected of being susceptible to stomach or esophageal cancer. Such individuals include those whose family medical history indicates above average incidence of stomach or esophageal cancer among family members and/or those who have already developed stomach or esophageal cancer and have been effectively treated who therefore face a risk of relapse and recurrence. Such individuals include those which have been diagnosed as having stomach or esophageal cancer including localized only or localized and metastasized stomach or esophageal cancer which has been resected or otherwise treated. The vaccines of the present invention may be to susceptible individuals prophylactically to prevent and combat primary and metastatic stomach or esophageal cancer.

The invention relates to compositions which are the active components of such vaccines or required to make the active components, to methods of making such compositions including the active components, and to methods of making and using vaccines.

The nucleotide sequence of the CRCA-1 transcript is set forth as SEQ ID NO:1 and the amino acid sequences of the various translation products are set forth in SEQ ID NOs:2-81. The present invention relates to isolated fragments of the CRCA-1 transcript that encode specific CRCA-1 translation products.

The present invention relates to recombinant vectors, including expression vectors, that comprise the CRCA-1 transcript or a fragment thereof. The present invention relates to recombinant vectors, including expression vectors that comprise nucleotide sequences that encode a CRCA-1 translation product or a functional fragment thereof.

The present invention relates to host cells which comprise such vectors and to methods of making CRCA-1 translation products using such recombinant cells.

The present invention relates to the isolated CRCA-1 transcript and to the isolated CRCA-1 translation products and to isolated antibodies specific for such products and to hybridomas which produce such antibodies.

The present invention relates to the isolated CRCA-1 translation products and functional fragments thereof. Accordingly, some aspects of the invention relate to isolated proteins that comprise at least one epitope of a CRCA-1 translation product.

Some aspects of the invention relate to the above described isolated proteins which are haptenized to render them more immunogenic. That is, some aspects of the invention relate to haptenized proteins that comprise at least one CRCA-1 translation product epitope.

Accordingly, some aspects of the invention relate to isolated nucleic acid molecules that encode proteins that comprise at least one CRCA-1 translation product epitope.

Naked DNA vaccines are described in PCT/US90/01515, which is incorporated herein by reference. Others teach the use of liposome mediated DNA transfer, DNA delivery using microprojectiles (U.S. Patent No. 4,945,050 issued July 31, 1990 to Sanford et al., which is incorporated herein by reference), and DNA delivery using electroporation. In each case, the DNA may be plasmid DNA that is produced in bacteria, isolated and administered to the animal to be treated. The plasmid DNA molecules are taken up by the cells of the animal where the sequences that encode the protein of interest are expressed. The protein thus produced provides a therapeutic or prophylactic effect on the animal.

The use of vectors including viral vectors and other means of delivering nucleic acid molecules to cells of an individual in order to produce a therapeutic and/or prophylactic immunological effect on the individual are similarly well known. Recombinant vaccines that employ vaccinia vectors are, for example, disclosed in U.S. Patent Number 5,017,487 issued May 21, 1991 to Stunnenberg *et al.* which is incorporated herein by reference.

In some cases, tumor cells from the patient are killed or inactivated and administered as a vaccine product. Berd *et al.* May 1986 *Cancer Research* **46**:2572-2577 and Berd *et al.* May 1991 *Cancer Research* **51**:2731-2734, which are incorporated herein

by reference, describes the preparation and use of tumor cell based vaccine products. According to some aspects of the present invention, the methods and techniques described in Berd *et al.* are adapted by using stomach or esophageal cancer cells instead of melanoma cells.

The manufacture and use of isolated translation products and fragments thereof useful for example as laboratory reagents or components of subunit vaccines are well known. One having ordinary skill in the art can isolate the CRCA-1 transcript or the specific portion thereof that encodes a CRCA-1 translation product or a fragment thereof. Once isolated, the nucleic acid molecule can be inserted it into an expression vector using standard techniques and readily available starting materials.

The recombinant expression vector that comprises a nucleotide sequence that encodes the nucleic acid molecule that encodes a CRCA-1 translation product or a fragment thereof or a protein that comprises the CRCA-1 translation product or a fragment thereof. The recombinant expression vectors of the invention are useful for transforming hosts to prepare recombinant expression systems for preparing the isolated proteins of the invention.

The present invention relates to a host cell that comprises the recombinant expression vector that includes a nucleotide sequence that encodes one or more CRCA-1 translation products or a fragment thereof or a protein that comprises one or more CRCA-1 translation products or a fragment thereof. Host cells for use in well known recombinant expression systems for production of proteins are well known and readily available. Examples of host cells include bacteria cells such as *E. coli,* yeast cells such as *S. cerevisiae*, insect cells such as *S. frugiperda*, non-human mammalian tissue culture cells chinese hamster ovary (CHO) cells and human tissue culture cells such as HeLa cells.

The present invention relates to a transgenic non-human mammal that comprises the recombinant expression vector that comprises a nucleic acid sequence that encodes the proteins of the invention. Transgenic non-human mammals useful to produce recombinant proteins are well known as are the expression vectors necessary and the techniques for generating transgenic animals. Generally, the transgenic animal comprises a recombinant expression vector in which the nucleotide sequence that encodes one or more CRCA-1 translation products or a fragment thereof or a protein that comprises the one or

more CRCA-1 translation products or a fragment thereof operably linked to a mammary cell specific promoter whereby the coding sequence is only expressed in mammary cells and the recombinant protein so expressed is recovered from the animal's milk.

In some embodiments, for example, one having ordinary skill in the art can, using well known techniques, insert such DNA molecules into a commercially available expression vector for use in well known expression systems such as those described herein.

The expression vector including the DNA that encodes a CRCA-1 translation product or a functional fragment thereof or a protein that comprises a CRCA-1 translation product or a functional fragment thereof is used to transform the compatible host which is then cultured and maintained under conditions wherein expression of the foreign DNA takes place. The protein of the present invention thus produced is recovered from the culture, either by lysing the cells or from the culture medium as appropriate and known to those in the art. The methods of purifying the CRCA-1 translation products or a fragment thereof or a protein that comprises the same using antibodies which specifically bind to the protein are well known. Antibodies which specifically bind to a particular protein may be used to purify the protein from natural sources using well known techniques and readily available starting materials. Such antibodies may also be used to purify the protein from material present when producing the protein by recombinant DNA methodology. The present invention relates to antibodies that bind to an epitope which is present on one or more CRCA-1 translation products or a fragment thereof or a protein that comprises the same. Antibodies that bind to an epitope which is present on the CRCA-1 translation product are useful to isolate and purify the protein from both natural sources or recombinant expression systems using well known techniques such as affinity chromatography. Immunoaffinity techniques generally are described in Waldman *et al.* 1991 *Methods of Enzymol.* **195**:391-396, which is incorporated herein by reference. Antibodies are useful to detect the presence of such protein in a sample and to determine if cells are expressing the protein. The production of antibodies and the protein structures of complete, intact antibodies, Fab fragments and $F(ab)_2$ fragments and the organization of the genetic sequences that encode such molecules are well known and are described, for example, in Harlow, E. and D. Lane (1988) *ANTIBODIES: A Laboratory Manual*, Cold

Spring Harbor Laboratory, Cold Spring Harbor, NY. which is incorporated herein by reference.

In some embodiments of the invention, transgenic non-human animals are generated. The transgenic animals according to the invention contain nucleotides that encode one or more CRCA-1 translation products or a fragment thereof or a protein that comprises the same under the regulatory control of a mammary specific promoter. One having ordinary skill in the art using standard techniques, such as those taught in U.S. Patent No. 4,873,191 issued October 10, 1989 to Wagner and U.S. Patent No. 4,736,866 issued April 12, 1988 to Leder, both of which are incorporated herein by reference, can produce transgenic animals which produce one or more CRCA-1 translation products or a fragment thereof or a protein that comprises the same. Preferred animals are goats and rodents, particularly rats and mice.

In addition to producing these proteins by recombinant techniques, automated peptide synthesizers may also be employed to produce one or more CRCA-1 translation products or a fragment thereof or a fragment thereof or a protein that comprises the same. Such techniques are well known to those having ordinary skill in the art and are useful if derivatives which have substitutions not provided for in DNA-encoded protein production.

In some embodiments, the protein that makes up a subunit vaccine or the cells or particles of a killed or inactivated vaccine may be haptenized to increase immunogenicity. In some cases, the haptenization is the conjugation of a larger molecular structure to one or more CRCA-1 translation products or a fragment thereof or a protein that comprises the same. In some cases, tumor cells from the patient are killed and haptenized as a means to make an effective vaccine product. In cases in which other cells, such as bacteria or eukaryotic cells which are provided with the genetic information to make and display a CRCA-1 translation product or a fragment thereof or a protein that comprises the same, are killed and used as the active vaccine component, such cells are haptenized to increase immunogenicity. Haptenization is well known and can be readily performed.

Methods of haptenizing cells generally and tumor cells in particular are described in Berd *et al.* May 1986 *Cancer Research* 46:2572-2577 and Berd *et al.* May

1991 *Cancer Research* **51**:2731-2734, which are incorporated herein by reference. Additional haptenization protocols are disclosed in Miller *et al.* 1976 *J. Immunol.* **117**(5:1):1591-1526.

Haptenization compositions and methods which may be adapted to be used to prepare haptenized CRCA-1 immunogens according to the present invention include those described in the following U.S. Patents which are each incorporated herein by reference: U.S. Patent Number 5,037,645 issued August 6, 1991 to Strahilevitz; U.S. Patent Number 5,112,606 issued May 12, 1992 to Shiosaka *et al.*; U.S. Patent Number 4,526716 issued July 2, 1985 to Stevens; U.S. Patent Number 4,329,281 issued May 11, 1982 to Christenson *et al.*; and U.S. Patent Number 4,022,878 issued May 10, 1977 to Gross. Peptide vaccines and methods of enhancing immunogenicity of peptides which may be adapted to modify CRCA-1 immunogens of the invention are also described in Francis *et al.* 1989 *Methods of Enzymol.* **178**:659-676, which is incorporated herein by reference. Sad *et al.* 1992 *Immunolology* **76**:599-603, which is incorporated herein by reference, teaches methods of making immunotherapeutic vaccines by conjugating gonadotropin releasing hormone to diphtheria toxoid. CRCA-1 immunogens may be similarly conjugated to produce an immunotherapeutic vaccine of the present invention. MacLean *et al.* 1993 *Cancer Immunol. Immunother.* **36**:215-222, which is incorporated herein by reference, describes conjugation methodologies for producing immunotherapeutic vaccines which may be adaptable to produce an immunotherapeutic vaccine of the present invention. The hapten is keyhole limpet hemocyanin which may be conjugated to a CRCA-1 immunogen.

Vaccines according to some aspects of the invention comprise a pharmaceutically acceptable carrier in combination with a CRCA-1 immunogen. Pharmaceutical formulations are well known and pharmaceutical compositions comprising such proteins may be routinely formulated by one having ordinary skill in the art. Suitable pharmaceutical carriers are described in *Remington's Pharmaceutical Sciences*, A. Osol, a standard reference text in this field, which is incorporated herein by reference. The present invention relates to an injectable pharmaceutical composition that comprises a pharmaceutically acceptable carrier and a CRCA-1 immunogen. The CRCA-1 immunogen is preferably sterile and combined with a sterile pharmaceutical carrier.

In some embodiments, for example, one or more CRCA-1 translation products or a fragment thereof or a fragment thereof or a protein that comprises the same can be formulated as a solution, suspension, emulsion or lyophilized powder in association with a pharmaceutically acceptable vehicle. Examples of such vehicles are water, saline, Ringer's solution, dextrose solution, and 5% human serum albumin. Liposomes and nonaqueous vehicles such as fixed oils may also be used. The vehicle or lyophilized powder may contain additives that maintain isotonicity (e.g., sodium chloride, mannitol) and chemical stability (e.g., buffers and preservatives). The formulation is sterilized by commonly used techniques.

An injectable composition may comprise the CRCA-1 immunogen in a diluting agent such as, for example, sterile water, electrolytes/dextrose, fatty oils of vegetable origin, fatty esters, or polyols, such as propylene glycol and polyethylene glycol. The injectable must be sterile and free of pyrogens.

The vaccines of the present invention may be administered by any means that enables the immunogenic agent to be presented to the body's immune system for recognition and induction of an immunogenic response. Pharmaceutical compositions may be administered parenterally, i.e., intravenous, subcutaneous, intramuscular.

Dosage varies depending upon known factors such as the pharmacodynamic characteristics of the particular agent, and its mode and route of administration; age, health, and weight of the recipient; nature and extent of symptoms, kind of concurrent treatment, frequency of treatment, and the effect desired. An amount of immunogen is delivered to induce a protective or therapeutically effective immune response. Those having ordinary skill in the art can readily determine the range and optimal dosage by routine methods.

The following examples are illustrative but are not meant to be limiting of the present invention.

EXAMPLES

Example 1

As stated above, a CRCA-1 translation product binding moiety is a CRCA-1 translation product ligand that may be an antibody, a protein, a polypeptide, a peptide or a

non-peptide. Peptides and non-peptide CRCA-1 specific ligands may be identified using well known technology.

Over the past 10 years, it has become recognized that the specific high-affinity interaction of a receptor and a ligand, for example a CRCA-1 translation product and an anti-CRCA-1 translation product antibody, has its basis in the 3-dimensional conformational space of the ligand and the complimentary 3-dimensional configuration of the region of the molecule involved in ligand binding. In addition, it has become recognized that various arrays of naturally-occurring amino acids, non-natural amino acids, and organic molecules can be organized in configurations that are unrelated to the natural ligands in their linear structure, but resemble the 3-dimensional structure of the natural ligands in conformational space and, thus, are recognized by receptors with high affinity and specificity. Furthermore, techniques have been described in the literature that permit one of ordinary skill in the art to generate large libraries of these arrays of natural amino acids, non-natural amino acids and organic compounds to prospectively identify individual compounds that interact with receptors with high affinity and specificity which are unrelated to the native ligand of that receptor. Thus, it is a relatively straightforward task for one of ordinary skill in the art to identify arrays of naturally occurring amino acids, non-natural amino acids, or organic compounds which can bind specifically and tightly to the CRCA-1 translation product, which bear no structural relationship to an anti-CRCA-1 translation product antibody.

To identify CRCA-1 translation product ligands that are peptides, those having ordinary skill in the art can use any of the well known methodologies for screening random peptide libraries in order to identify peptides which bind to the CRCA-1 translation product. In the most basic of methodologies, the peptides which bind to the target are isolated and sequenced. In some methodologies, each random peptide is linked to a nucleic acid molecule which includes the coding sequence for that particular random peptide. The random peptides, each with an attached coding sequence, are contacted with a CRCA-1 translation product and the peptides which are unbound to the CRCA-1 translation product are removed. The nucleic acid molecule which includes the coding sequence of the peptide that binds to the CRCA-1 translation product can then be used to determine the amino acid sequence of the peptide as well as produce large quantities of the

peptide. It is also possible to produce peptide libraries on solid supports where the spatial location on the support corresponds to a specific synthesis and therefore specific peptide. Such methods often use photolithography-like steps to create diverse peptide libraries on solid supports in which the spatial address on the support allows for the determination of the sequence.

The production of organic compound libraries on solid supports may also be used to produce combinatorial libraries of non-peptide compounds such as oligonucleotides and sugars, for example. As in the case of peptide libraries on solid supports, the spatial location on the support corresponds to a specific synthesis and therefore specific compound. Such methods often use photolithography-like steps to create diverse compound libraries on solid supports in which the spatial address on the support allows for the determination of the synthesis scheme which produced the compound. Once the synthesis scheme is identified, the structure of the compound can become known.

Gallop *et al.* 1994 *J. Medicinal Chemistry* **37**:1233, which is incorporated herein by reference, provides a review of several of the various methodologies of screening random peptide libraries and identifying peptides from such libraries which bind to target proteins. Following these teachings, CRCA-1 translation product specific ligands that are peptides and that are useful as CRCA-1 translation product specific binding moieties may be identified by those having ordinary skill in the art.

Peptides and proteins displayed on phage particles are described in Gallop *et al. Supra*. Random arrays of nucleic acids can be inserted into genes encoding surface proteins of bacteriophage which are employed to infect bacteria, yielding phage expressing the peptides encoded by the random array of nucleotides on their surface. These phage displaying the peptide can be employed to determine whether those peptides can bind to specific proteins, receptors, antibodies, etc. The identity of the peptide can be determined by sequencing the recombinant DNA from the phage expressing the peptide. This approach has the potential to yield vast arrays of peptides in a library (up to 10^9 unique peptides). This technique has been employed to identify novel binding peptides to the fibrinogen receptor on platelets, which bear no sequence homology to the natural occurring ligands of this receptor (Smith *et al.*, 1993 *Gene* **128**:37, which is incorporated herein by reference). Similarly, this technique has been applied to identify peptides which bind to

the MHC class II receptor (Hammer *et al.*, 1993 *Cell* **74**:197, which is incorporated herein by reference) and the chaperonin receptor (Blond-Elguindi *et al.*, 1993 *Cell* **75**:717, which is incorporated herein by reference).

Peptides displayed on plasmids are described in Gallop *et al. Supra.* In this approach, the random oligonucleotides which encode the library of peptides can be expressed on a specific plasmid whose expression is under the control of a specific promoter, such as the lac operon. The peptides are expressed as fusion proteins coupled to the Lac I protein, under the control of the lac operon. The fusion protein specifically binds to the lac operator on the plasmid and so the random peptide is associated with the specific DNA element that encodes it. In this way, the sequence of the peptide can be deduced, by PCR of the DNA associated with the fusion protein. These proteins can be screened in solution phase to determine whether they bind to specific receptors. Employing this approach, novel substrates have been identified for specific enzymes (Schatz 1993).

A variation of the above technique, also described in Gallop *et al. Supra*, can be employed in which random oligonucleotides encoding peptide libraries on plasmids can be expressed in cell-free systems. In this approach, a molecular DNA library can be constructed containing the random array of oligonucleotides, which are then expressed in a bacterial in vitro transcription/translation system. The identity of the ligand is determined by purifying the complex of nascent chain peptide/polysome containing the mRNA of interest on affinity resins composed of the receptor and then sequencing following amplification with RT-PCR. Employing this technique permits generation of large libraries (up to 10^{11} recombinants). Peptides which recognize antibodies specifically directed to dynorphin have been identified employing this technique (Cull *et al.*, 1992 *Proc. Natl. Acad. Sci. USA* **89**:1865, which is incorporated herein by reference).

Libraries of peptides can be generated for screening against a receptor by chemical synthesis. For example, simultaneous preparation of large numbers of diverse peptides have been generated employing the approach of multiple peptide synthesis as described in Gallop *et al. Supra.* In one application, random peptides are generated by standard solid-phase Merrifield synthesis on polyacrylamide microtiter plates (multipin synthesis) which are subsequently screened for their ability to compete with receptor binding in a standard competitive binding assay (Wang *et al.*, 1993 *Bioorg. Med. Chem.*

Lett. 3:447, which is incorporated herein by reference). Indeed, this approach has been employed to identify novel binding peptides to the substance P receptor (Wang *et al. Supra*). Similarly, peptide libraries can be constructed by multiple peptide synthesis employing the "tea bag" method in which bags of solid support resin are sequentially incubated with various amino acids to generate arrays of different peptides (Gallop *et al. Supra*). Employing this approach, peptides which bind to the integrin receptor (Ruggeri *et al.*, 1986 *Proc. Natl. Acad. Sci. USA* 83:5708, which is incorporated herein by reference) and the neuropeptide Y receptor (Beck-Sickinger *et al.*, 1990 *Int. J. Peptide Protein Res.* 36:522, which is incorporated herein by reference) have been identified.

In general, the generation and utility of combinatorial libraries depend on (1) a method to generate diverse arrays of building blocks, (2) a method for identifying members of the array that yield the desired function, and (3) a method for deconvoluting the structure of that member. Several approaches to these constraints have been defined.

The following is a description of methods of library generation which can be used in procedures for identifying CRCA-1 translation product specific ligands according to the invention.

Modifications of the above approaches can be employed to generate libraries of vast molecular diversity by connecting together members of a set of chemical building blocks, such as amino acids, in all possible combinations (Gallop *et al. Supra*) In one approach, mixtures of activated monomers are coupled to a growing chain of amino acids on a solid support at each cycle. This is a multivalent synthetic system.

Also, split synthesis involves incubating the growing chain in individual reactions containing only a single building block (Gallop *et al. Supra*). Following attachment, resin from all the reactions are mixed and apportioned into individual reactions for the next step of coupling. These approaches yield a stochastic collection of n^x different peptides for screening, where n is the number of building blocks and x is the number of cycles of reaction.

Alternatively, arrays of molecules can be generated in which one or more positions contain known amino acids, while the remainder are random (Gallop et al. *Supra*). These yield a limited library which is screened for members with the desired activity. These members are identified, their structure determined, and the structure

regenerated with another position containing defined amino acids and screened. This iterative approach ultimately yields peptides which are optimal for recognizing the conformational binding pocket of a receptor.

In addition, arrays are not limited to amino acids forming peptides, but can be extended to linear and nonlinear arrays of organic molecules (Gordon *et al.*, 1994 *J. Medicinal Chemistry* 37:1385, which is incorporated herein by reference). Indeed, employing this approach of generating libraries of randomly arrayed inorganic building blocks, ligands which bound to 7-transmembrane receptors were identified (Zuckermann *et al.*, 1994 *J. Med. Chem.* 37:2678, which is incorporated herein by reference).

Libraries are currently being constructed which can be modified after synthesis to alter the chemical side groups and bonds, to give "designer" arrays to test for their interaction with receptors (Osteresh *et al.*, 1994 *Proc. Natl. Acad. Sci. USA* 91:11138, which is incorporated herein by reference). This technique, generating "libraries from libraries", was applied to the permethylation of a peptide library which yielded compounds with selective antimicrobial activity against gram positive bacteria.

Libraries are also being constructed to express arrays of pharmacological motifs, rather than specific structural arrays of amino acids (Sepetov *et al.*, 1995 *Proc. Natl. Acad. Sci. USA* 92:5426, which is incorporated herein by reference). This technique seeks to identify structural motifs that have specific affinities for receptors, which can be modified in further refinements employing libraries to define structure-activity relationships. Employing this approach of searching motif libraries, generating "libraries of libraries", reduces the number of component members required for screening in the early phase of library examination.

The following is a description of methods of identifying CRCA-1 translation product specific ligands according to the invention from libraries of randomly generated molecules.

Components in the library which interact with receptors may be identified by their binding to receptors immobilized on solid support (Gordon *et al. Supra*).

They may also be identified by their ability to compete with native ligand for binding to cognate receptors in solution phase (Gordon *et al. Supra*).

Components may be identified by their binding to soluble receptors when those components are immobilized on solid supports (Gordon *et al. Supra*).

Once a member of a library which binds receptors has been identified, the structure of that member must be deconvoluted (deduced) in order to identify the structure and generate large quantities to work with, or develop further analogs to study structure-activity relationships. The following is a description of methods of deconvolution for deducing the structure of molecules identified as potential CRCA-1 translation product specific ligands according to the invention.

Peptide libraries may be expressed on the surface of bacteriophage particles (Gallop *et al. Supra*). Once the peptide interacting with the receptor has been identified, its structure can be deduced by isolating the DNA from the phage and determining its sequence by PCR.

Libraries expressed on plasmids, under the control of the Lac operon can be deconvoluted since these peptides are fused with the lac I protein which specifically interacts with the lac operon on the plasmid encoding the peptide (Gallop *et al. Supra*) The structure can be deduced by isolating that plasmid attached to the lac I protein and deducing the nucleotide and peptide sequence by PCR.

Libraries expressed on plasmids can also be expressed in cell-free systems employing transcription/translation systems (Gallop *et al. Supra*). In this paradigm, the protein interacting with receptors is isolated with its attached ribosome and mRNA. The sequence of the peptide is deduced by RT-PCR of the associated mRNA.

Library construction can be coupled with photolithography, so that the structure of any member of the library can be deduced by determining its position within the substrate array (Gallop *et al. Supra*). This technique is termed positional addressability, since the structural information can be deduced by the precise position of the member.

Members of a library can also be identified by tagging the library with identifiable arrays of other molecules (Ohlmeyer *et al.*, 1993 *Proc. Natl. Acad. Sci. USA* 90:10922, which is incorporated herein by reference, and Gallop *et al. Supra*). This technique is a modification of associating the peptide with the plasmid of phage encoding the sequence, described above. Some methods employ arrays of nucleotides to encode the

sequential synthetic history of the peptide. Thus, nucleotides are attached to the growing peptide sequentially, and can be decoded by PCR to yield the structure of the associated peptide. Alternatively, arrays of small organic molecules can be employed as sequencable tags which encode the sequential synthetic history of the peptide. Thus, nucleotides are attached to the growing peptide sequentially, and can be decoded by PCR to yield the structure of the associated peptide. Alternatively, arrays of small organic molecules can be employed as sequencable tags which encode the sequential synthetic history of the library member.

Finally, the structure of a member of the library can be directly determined by amino acid sequence analysis.

The following patents, which are each incorporated herein by reference, describe methods of making random peptide or non-peptide libraries and screening such libraries to identify compounds that bind to target proteins. As used in the present invention, CRCA-1 translation product can be the targets used to identify the peptide and non-peptide ligands generated and screened as disclosed in the patents.

U.S. Patent Number 5,270,170 issued to Schatz et al. on December 14, 1993, and U.S. Patent Number 5,338,665 issued to Schatz et al. on August 16, 1994, which are both incorporated herein by reference, refer to peptide libraries and screening methods which can be used to identify CRCA-1 translation product ligands.

U.S. Patent No. 5,395,750 issued to Dillon et al. on March 7, 1995, which is incorporated herein by reference, refers to methods of producing proteins which bind to predetermined antigens. Such methods can be used to produce CRCA-1 translation product ligands.

U.S. Patent No. 5,223,409 issued to Ladner et al. on June 29, 1993, which is incorporated herein by reference, refers to the directed evolution to novel binding proteins. Such proteins may be produced and screened as disclosed therein to identify CRCA-1 translation product ligands.

U.S. Patent No. 5,366,862 issued to Venton et al. on November 22, 1994, which is incorporated herein by reference, refers to methods for generating and screening useful peptides. The methods herein described can be used to identify CRCA-1 translation product ligands.

U.S. Patent No. 5,340,474 issued to Kauvar on August 23, 1994 as well as U.S. Patent No. 5,133,866, U.S. Patent No. 4,963,263 and U.S. Patent No. 5,217,869, which are each incorporated herein by reference, can be used to identify CRCA-1 translation product ligands.

U.S. Patent No. 5,405,783 issued to Pirrung et al. on April 11, 1995, which is incorporated herein by reference, refers to large scale photolithographic solid phase synthesis of an array of polymers. The teachings therein can be used to identify CRCA-1 translation product ligands.

U.S. Patent No. 5,143,854 issued to Pirrung et al. on September 1, 1992, which is incorporated herein by reference, refers to a large scale photolithographic solid phase synthesis of polypeptides and receptor binding screening thereof.

U.S. Patent No. 5,384,261 issued to Winkler et al. on January 24, 1995, which is incorporated herein by reference, refers to very large scale immobilized polymer synthesis using mechanically directed flow patterns. Such methods are useful to identify CRCA-1 translation product ligands.

U.S. Patent No. 5,221,736 issued to Coolidge et al. on June 22, 1993, which is incorporated herein by reference, refers to sequential peptide and oligonucleotide synthesis using immunoaffinity techniques. Such techniques may be used to identify CRCA-1 translation product ligands.

U.S. Patent No. 5,412,087 issued to McGall et al. on May 2, 1995, which is incorporated herein by reference, refers to spatially addressable immobilization of oligonucleotides and other biological polymers on surfaces. Such methods may be used to identify CRCA-1 translation product ligands.

U.S. Patent No. 5,324,483 issued to Cody et al. on June 28, 1994, which is incorporated herein by reference, refers to apparatus for multiple simultaneous synthesis. The apparatus and method disclosed therein may be used to produce multiple compounds which can be screened to identify CRCA-1 translation product ligands.

U.S. Patent No. 5,252,743 issued to Barrett et al. on October 12, 1993, which is incorporated herein by reference, refers to spatially addressable immobilization of anti-ligands on surfaces. The methods and compositions described therein may be used to identify CRCA-1 translation product ligands.

U.S. Patent No. 5,424,186 issued to Foder et al. on June 13, 1995, which is incorporated herein by reference, refers to a very large scale immobilized polymer synthesis. The method of synthesizing oligonucleotides described therein may be used to identify CRCA-1 translation product ligands.

U.S. Patent No. 5,420,328 issued to Campbell on May 30, 1995, which is incorporated herein by reference, refers to methods of synthesis of phosphonate esters. The phosphonate esters so produced may be screened to identify compounds which are CRCA-1 translation product ligands.

U.S. Patent No. 5,288,514 issued to Ellman on February 22, 1994, which is incorporated herein by reference, refers to solid phase and combinatorial synthesis of benzodiazepine compounds on a solid support. Such methods and compounds may be used to identify CRCA-1 translation product ligands.

As noted above, CRCA-1 translation product ligands may also be antibodies and fragments thereof. Indeed, antibodies raised to unique determinants of these receptors will recognize that protein, and only that protein and, consequently, can serve as a specific targeting molecule which can be used to direct novel diagnostics and therapeutics to this unique marker. In addition, these antibodies can be used to identify the presence of CRCA-1 translation product or fragments there of in biological samples, to diagnose the presence of colorectal cancer cells *in vitro*.

Example 2

Some members of the family of receptor guanylyl cyclases have been observed to undergo alternative splicing. Rat GCA, a receptor for the natriuretic peptides ANP and BNP, is expressed as an alternatively spliced form, GCA1, with the insertion of a 9 bp sequence in the extracellular juxtamembrane region (Tallerico-Melnyk, et al., Biochemical & Biophysical Research Communications. *209:* 930-935, 1995). The impact of this sequence alteration on binding and catalytic function remains unclear. Rat GCB, a receptor for C-type natriuretic peptide, is expressed as an alternatively spliced form, GCB2, with the deletion of 75 bp in the intracellular juxtamembrane region (Ohyama, et al., Biochemical & Biophysical Research Communications. *183:* 743-749, 1992.). This variant is predominantly expressed in the central nervous system (Francoeur, et al., Clinical and Experimental Pharmacology and Physiology. *Suppl. 1:* S172-S174, 1995.), possesses

the same binding affinity as the full length GCB, but ligand-receptor interaction is not coupled to guanylyl cyclase activation or cGMP production. The bovine ANP clearance receptor, a truncated natriuretic peptide receptor guanylyl cyclase, is alternatively spliced to form a variant in which Ser^{472}-Gly^{473} is replaced with Cys^{472}, thereby forming a variant with an additional cysteine residue (Mizuno, et al. The Journal of Biological Chemistry. *268:* 5162-5167, 1993.). The wild type and variant clearance receptors possess identical functional characteristics. A deletion of 159 nucleotides has been reported in the rat GCC catalytic domain (London, et al., American Journal of Physiology. *273:* G93-G105, 1997.). However, this transcript appears to arise from a different gene rather than by alternative splicing. The significance of this sequence alteration on catalytic function remains unknown.

The present studies demonstrate that in humans, GCC is expressed as the full-length wild type transcript and an alternatively spliced transcript lacking 142 bases in the region encoding the extracellular ligand-binding domain. Splicing occurs at an alternative 5' acceptor site in exon 1. This results in a shift in the reading frame producing a transcript that encodes only 26 amino acids of the wild type transcript of which 23 amino acids form the signal peptide (De Sauvage et al., The Journal of Biological Chemistry. *266:* 17912-17918, 1991, which is incorporated herein by reference.). Expression of the alternatively spliced variant of GCC parallels that of wild type GCC and is limited to intestinally-derived tissues (Carrithers, et al., Gastroenterology. *107:* 1653-1661, 1994; Carrithers, et al., Proc. Natl. Acad. Sci. USA. *93:* 14827-14832, 1996; Carrithers, et al., Dis. Colon. Rectum. *39:* 171-181, 1996).

METHODS

Cell Culture and Clinical Specimens.

T84 human colon cells (American Type Culture Collection, Rockville, MD) were grown to confluence in DMEM/F12 (Gibco/BRL-Life Technologies, Gaithersburg, MD) in 150 cm^2 tissue culture flasks. Tissues were obtained under an Institutional Review Board-approved protocol from Thomas Jefferson University Hospital and the Cooperative Human Tissue Network (Philadelphia, PA). Upon receipt, tissue samples were snap frozen in liquid nitrogen and pulverized using a mortar and pestle.

Nucleic Acid Extraction.

Total RNA was extracted by a modified version of the acid guanidinium thiocyanate/phenol/chloroform method using a single reagent (TriZol reagent; Gibco/BRL). RNA was quantified by UV spectroscopy. The Oligotex mRNA Kit (Qiagen, Chatsworth, CA) was employed to isolate mRNA from total RNA. RNA preparations were stored in diethylpyrocarbonate-treated water (Rnase-free) at -80°C.

Reverse Transcription-Polymerase Chain Reaction.

RT-PCR was performed using 0.2 mL thermal cycling tubes (TKR Biotech Products, Huntingdon Valley, PA) in a DeltaCycler II System thermocycler (Ericomp, San Diego, CA). Reverse transcription of RNA (~3.5 μg) was performed with 0.25 units of avian myeloblastosis virus reverse transcriptase XL per μL (Promega, Madison, WI) in a reaction containing 10 mM Tris-HCl (pH 8.3), 50 mM KCl, 4 mM $MgCl_2$, 1 mM each of dATP, dCTP, dGTP, dTTP, 1 unit of RNase inhibitor per μL, and 1 μM antisense primer in a total volume of 20 μL. Thermal cycling proceeded for one cycle at 58°C for 30 min, 99°C for 5 min, and 4°C for 5 min. The resultant cDNA was subjected to PCR in the same reaction tube and included 2.5 units of *Taq* polymerase (Promega) in 100 μL of: 10 mM Tris-HCl, 50 mM KCl, 5.5 mM $MgCl_2$, and 0.5 μM sense primer. Incubation and thermal cycling conditions were: 95°C for 2 min, one cycle; 94°C for 30 sec, 58°C for 30 sec, and 72°C for 90 sec, 35 cycles; and 72°C for 7 min, one cycle. Reaction products were separated by electrophoresis on 4% NuSieve® 3:1 agarose (FMC Bioproducts, Rockland, ME) and amplification products visualized by ethidium bromide. Primers specific for human β-actin (CLONTECH, Palo Alto, CA) were used as a positive control. The identity of amplification products was confirmed by sequence analysis.

Cloning GCC_{var}.

RT-PCR was performed on T84 total RNA using GCC specific sense (81 - 96) and antisense (1834 - 1853) primers. Nucleotide numbering refers to GenBank sequence S57551 (Singh, et al., Biochemical & Biophysical Research Communications. *179:* 1455-1463, 1991 which is incorporated herein by reference). Amplification products were separated on a 1% agarose (Sigma, St. Louis, MO) gel by electrophoresis. The sole RT-PCR product, a fragment containing the extracellular and transmembrane regions of GCC (~1772 bp), was extracted from the agarose, ligated into the pGem-T Easy vector (Promega), and transformed into DH5α competent cells (Gibco/BRL). Plasmid DNA was

isolated from bacteria, sequenced, and sequences were analyzed using the program DNA Strider™.

Semi-Quantitative RT-PCR.

RT-PCR was performed on total RNA from human colon tissue using specific sense (126 – 147) and antisense (416 – 435) primers that flank the deleted region. One pmol of α^{32}P-dCTP (6,000 Ci/mmol) (Amersham Life Science, Cleveland, OH) was added to the PCR reaction mixture to allow for radiolabeled nucleotide incorporation into the amplification products. The resultant bands, GCC_{var} (168 bp) and GCC (309 bp), were excised from the gel and placed into 7 mL scintillation vials containing ScintiVerse™ BD scintillation fluid (Fisher Scientific, Pittsburgh, PA, U.S.A.). Samples were counted in a 1900 TR liquid scintillation analyzer (Packard Instruments, Meriden, CT) to quantify ^{32}P levels. The ratio of GCC_{var} to GCC was used as a measure of the relative expression of these transcripts. Radioactivity in amplification products was normalized to the number of dCTP residues in each product (88 in GCC_{var}; 160 in GCC). Employing this technique, 5 different human colon tissue samples were analyzed in duplicate.

Protein Expression and Detection.

The GCC_{var} cDNA transcript was tagged with the c-myc epitope (EQKLISEEDL - SEQ ID NO:83) by overlap extension using the polymerase chain reaction. The GCC_{var} cDNA clone was amplified, and the c-myc epitope was inserted proximal to the predicted stop codon. The tagged GCC_{var} cDNA was ligated into the pRc/CMV2 expression vector (Invitrogen, Carlsbad, CA) and transfected into COS-7 cells using the lipofectamine reagent (Gibco/BRL). The pRc/CMV2 vector was used as a negative control, and a c-myc epitope tagged GCC clone in the expression vector pMT2 was used as a positive control. Cells were grown for 24 hours post-transfection in 2 mL Opti-Mem reduced serum medium (Gibco/BRL). The media were collected from atop the cells, and the cells were lysed and proteins solubilzed using a solution of 1X PBS, 1% Triton X®-100, 12 mM sodium deoxycholate, 3.5 mM sodium dodecyl sulfate, 0.5 μg/mL leupeptin, 1mM EDTA, 1 μg/mL pepstatin, and 0.2 mM PMSF. Protein concentrations were determined using the Bio-Rad Protein Assay (Hercules, CA). Approximately 140 μg of total cell lysate protein and 1.4 mL of collected medium were subjected to immunoprecipitation with 1 μg c-myc antibody (c-myc (Ab-1); CALBIOCHEM, La Jolla,

CA) in the presence of Protein G immobilized on 4% beaded agarose (Sigma). Immunoprecipitate was separated on a pre-cast 4 – 20% Tris-Glycine polyacrylamide gel (Fisher Scientific) and transferred to a PVDF membrane by electroblotting overnight at 15 volts. The blot was blocked with a solution containing 10 mM Tris·HCl, pH 8.0, 150 mM NaCl, 0.2% TWEEN®-20, and 5% nonfat powdered milk. The membrane was incubated with 40 μg c-myc antibody, washed, incubated with anti-rabbit IgG-HRP (Santa Cruz Biotechnology, Santa Cruz, CA) at a 1:10,000 dilution, and washed again. Proteins were detected by autoradiography (~17 hour exposure) using the ECL™ Western blotting system (Amersham Life Science).

Miscellaneous.

The mean and standard error of the mean were calculated employing Microsoft Excel™. Results are representative of at least 3 experiments. Experiments were conducted at least in duplicate. All reagents were commercially obtained and of the highest analytical grade.

RESULTS

Employing RT-PCR, a cDNA encoding GCC_{var} was isolated. The sequence of the GCC_{var} clone is identical to that of GCC except for a 142 bp deletion occurring 72 bp after the translational start codon. Splicing occurs within a consensus sequence for 5' donor sites. The GCC cDNA transcript contains the sequence C-A-G-G-T-G-A-G-T (SEQ ID NO:84), an exact match of the 5' splice site consensus sequence (C/A)-A-G-G-U-(A/G)-A-G-U (SEQ ID NO:85). Alternative splicing occurs between the two guanine nucleotides and represents a premature end of the first exon for GCC_{var}. In the wild type GCC transcript, the first exon terminates 214 bp after the initiating A-T-G. Truncation of the first exon in GCC_{var} causes a shift in the translational reading frame. Assuming the wild type start codon is competent, the GCC_{var} transcript encodes a 26 amino acid peptide identical to the first 25 amino acids of the GCC protein. However, the 26th residue will be changed from a valine to an alanine, and the 27th codon will produce a stop signal.. In the wild type GCC transcript, the end of the first exon produces an alanine as the 72nd amino acid and, along with two nucleotides from the second exon, produces a glycine at the 73rd position.

Sense (126 – 147) and antisense (416 – 435) primers were used to detect both GCC_{var} (168 bp) and GCC (309 bp) in total RNA from human colon, ileum, and colon carcinoma tissues and the human carcinoma cell lines T84, Caco-2, SW620, SW1116, SW1463, and NCI. Employing these primers, neither GCC nor GCC_{var} was detected in total RNA from human pancreas, uterus, lung, kidney, or the cell line HS766T. Similarly, a sense primer that spans the deleted region (180 – 192 + 335 - 343) and an antisense primer (677 - 699) were used to specifically detect GCC_{var} (378 bp) in total RNA from colon, ileum, colon carcinoma tissues and T84, Caco-2, SW620, SW1116, SW1463, and NCI cells but not in pancreas, uterus, lung, kidney, or the cell line HS766T. In a previous study, sense (828 – 850) and antisense (1068 – 1090) primers were used to demonstrate that in humans GCC is specifically expressed only in intestinal, but not in extraintestinal, tissues. These primers amplify a region downstream from the deletion in which GCC and GCC_{var} are identical in nucleotide sequence resulting in amplification products from these different transcripts that are indistinguishable. In the present study, a 265 bp product was detected using this primer set confirming the expression of GCC and/or GCC_{var} in colon, ileum, colon carcinoma tissues and T84, Caco-2, SW620, SW1116, SW1463, and NCI cells but not in pancreas, uterus, lung, kidney, or the cell line HS766T. The identity of amplification products was verified by sequence analysis. Primers specific for β-actin produced an amplification product for each sample, demonstrating the integrity of RNA employed in these analyses.

T84 cell and human colon mRNA was isolated from total RNA. These samples were screened employing the same primers used to investigate GCC_{var} expression in total RNA. Specific primers that flank the deleted region detected both GCC (309 bp) and GCC_{var} (168 bp) in colon and T84 mRNA. Similarly, GCC_{var} was specifically detected in colon and T84 mRNA by employing a sense primer that spans the deleted region producing a 378 bp amplification product. GCC and/or GCC_{var} also were detected using primers that amplify an identical region in both transcripts and, thus, produce a single 265 bp product. Again, primers specific for β-actin produced an amplification product for each sample, demonstrating the integrity of mRNA employed in these analyses.

Specific primers that flank the deleted region were used to compare the total RNA expression levels of GCC and GCC_{var} isolated from human colon. Semi-quantitative

RT-PCR was performed employing α^{32}P-dCTP in the PCR reaction mixture. Radioactivity in amplification products was normalized to the number of dCTP residues in each product (88 in GCC_{var}; 160 in GCC). Total RNA for GCC_{var} was 4.4 ± 0.7 (mean ± SEM, n=5)-fold more abundant than that for GCC in human intestine (Table 1).

To detect the expression of the suspected 26 amino acid GCC_{var} peptide, a c-myc epitope was inserted proximal to the stop codon at position 27. Recombinant expression of cDNA encoding for GCC_{var} did not produce a detectable protein product in either the media or cellular lysate samples. The peptide was expected to be 4 kDa in size including the epitope tag and an intact signal peptide. If the signal peptide was cleaved, the peptide would have been 1.4 kDa. No distinct protein bands were identified in comparison to the negative control, expression vector alone. Recombinant expression of the positive control, cDNA encoding GCC, produced a distinct large molecular weight protein product (~120 kDa) in the cellular lysate sample. This corresponds to the reported size of the mature GCC protein.

DISCUSSION

The present studies demonstrate that GCC undergoes alternative splicing producing the variant transcript GCC_{var} in human intestinal cells. GCC and GCC_{var} are identical except for a 142 bp deletion that occurs at the 3' end of the 1st exon in the GCC_{var} transcript. Truncation of the 1st exon causes a frame-shift resulting in a translation stop signal at the 27th codon. The native translation start site for GCC, however, may not remain active in GCC_{var}. Recombinant expression studies using GCC_{var} with a c-myc epitope tag did not produce any detectable protein product when the tag was inserted in-frame with the native start site. This indicates that either the native start site is no longer active or any peptide product is degraded by proteolysis upon creation.

GCC and GCC_{var} were detected in total RNA from human colon, ileum, colon carcinoma tissues and T84, Caco-2, SW620, SW1116, SW1463, and NCI cells but not in total RNA from human lung, kidney, pancreas, uterus, and the cell line HS766T demonstrating the specificity of expression of these transcripts in intestinal, but not extra-intestinal, tissues and cells. GCC_{var} was detected in total and mRNA from human intestinal cells demonstrating that this transcript is not an aborted product of RNA editing confined to the nucleus, but is processed to a mature cytoplasmic message.

The present work supports previous studies examining the specificity of expression of GCC in human tissues, in which, employing primers that yield identical amplification products from GCC and GCC_{var}, amplification products were detected only in tissues and cells derived from the intestine, but not from those derived from extraintestinal tissues. Taken together, these data support the suggestion that in humans GCC and GCC_{var} are specifically expressed in intestinally derived tissues only.

Alternative splicing reflects the presence of different combinations of splice sites within a precursor mRNA. The different transcripts encode variant proteins, some with distinct physiological functions. Splicing occurs by a two-step process. First, pre-mRNA is cleaved at the 5' splice site creating a linear first exon RNA species and an intron-second exon RNA species in a lariat configuration. The guanosine at the 5' splice site and the 2'-hydroxyl of an adenosine near the 3' splice site form a 2'-5' phosphodiester bond, the RNA branch point, inducing formation of the lariat. Secondly, the pre-mRNA is cleaved at the 3' splice site and the exons are ligated together forming the mRNA transcript and the excised intron in a lariat configuration. There are consensus RNA sequences for both the 5' donor site and the 3' acceptor site. However, the location of the branch point may be more important for 3' splice site determination since it has been suggested that a scanning process identifies the first A-G downstream of the branch point. RNA secondary structure, steric constraints, splice junction affinity, and splice site competition all regulate alternate splicing.

GCC_{var} appears to be unique compared to other variants in the guanylyl cyclase family because it is the first reported to encode premature termination of translation. Of the guanylyl cyclase splice variants, each retains the correct translational reading frame despite the addition or deletion of nucleotides. The 9 bp insertion that forms GCA1, which is co-expressed with GCA in the rat adrenal and renal papilla, may alter ligand affinity, signal transduction, or receptor internalization. GCB2 has a 75 bp deletion which produces a natriuretic peptide receptor uncoupled from guanylyl cyclase activation. The variant form of the ANP clearance receptor, which contains an extra cysteine residue, is functionally indistinguishable from the native receptor. The extra cysteine in variant clearance receptors may form disulfide-linked oligomers that are larger than the dimers formed by wild type receptors.

In conclusion, the present studies demonstrate that in humans, GCC is expressed as the full-length wild type transcript and an alternatively spliced transcript lacking 142 bases deleted from the region encoding the extracellular ligand-binding domain. Alternative splicing results from the use of an alternative 5' splice acceptor site in exon 1. Alternative splicing results in a shift in the reading frame and the formation of a premature translation termination signal at the 27th codon. The specificity of expression of the alternatively spliced variant of GCC parallels that of wild type GCC and is limited to intestinally derived tissues. Interestingly, intestinal cells contain more GCCvar than wild type GCC transcript, the significance of which remains unclear. However, manipulating the relative quantities of GCC and GCC_{var} might be one mechanism by which intestinal cells regulate functional GCC expression.

Table 1. Comparison of GCC and GCC_{var} expression in human intestine.[a]

	Ratio of GCC_{var}/GCC[b]
Mean[c]	**4.4**
SEM	**0.7**
High	**6.0**
Low	**3.1**

[a]RT-PCR was performed using specific primers that flank the deleted region. Total RNA from human colon was reverse transcribed and amplified using a PCR mixture that contained α^{32}P-dCTP. PCR products were resolved by agarose gel electrophoresis. Amplification products, GCC_{var} (168 bp) and GCC (309 bp), were excised and incorporated ^{32}P quantified by scintillation spectroscopy. Five different colon samples were employed, and each sample was analyzed at least in duplicate.
[b]Ratio of GCC_{var} (CPM/dCTP in amplification product) to GCC (CPM/dCTP in amplification product). Radioactivity in amplification products were normalized to the number of dCTP residues in that product (88 in GCCvar; 160 in GCC).
[c]n=5.

CLAIMS

1. An *in vitro* method of screening an individual for stomach or esophageal cancer cells comprising the steps of examining a sample of extraintestinal tissue and/or body fluids from an individual to determine whether CRCA-1 transcript is being expressed by cells in said sample wherein expression of said CRCA-1 transcript the possible presence of stomach or esophageal cancer cells in said sample.

2. The method of claim 1 wherein expression of said CRCA-1 transcript by said cells is determined by polymerase chain reaction wherein said sample is contacted with primers that selectively amplify said CRCA-1 transcript or cDNA generated therefrom.

3. The method of claim 1 wherein said sample is body fluid.

4. The method of claim 1 wherein said sample is blood.

5. The method of claim 1 wherein said sample is lymph node tissue.

6. An *in vitro* method of confirming that a tumor cell removed from a patient suspected of having stomach or esophageal cancer is a stomach or esophageal tumor cell comprising the steps of determining whether a tumor cell expresses CRCA-1 transcript wherein expression of CRCA-1 transcript indicates that the tumor cell is a stomach or esophageal tumor cell.

7. The method of claim 6 wherein expression of said CRCA-1 transcript by said tumor cells is determined by polymerase chain reaction wherein said cell is contacted with primers that selectively amplify said CRCA-1 transcript or cDNA generated therefrom.

8. An *in vitro* method of screening an individual for stomach or esophageal cancer comprising the steps of examining a sample of extraintestinal tissue and/or body fluids from an individual to determine whether a CRCA-1 transcript is present in said

sample, wherein the presence of a CRCA-1 transcript in said sample suggests that said individual may have stomach or esophageal cancer.

9. The method of claim 8 wherein said sample is body fluid.

10. The method of claim 8 wherein said sample is blood.

11. The method of claim 8 wherein said sample is lymph node tissue.

12. The method of claim 8 wherein said CRCA-1 transcript is detected by polymerase chain reaction assay using primers which specifically amplify CRCA-1 transcript sequences.

13. A method of diagnosing an individual who has stomach or esophageal cancer comprising the step of examining a sample of extraintestinal tissue and/or body fluids from an individual who is suspected of having stomach or esophageal cancer to detect the presence of CRCA-1 transcript or CRCA-1 translation product, wherein the presence of CRCA-1 transcript or CRCA-1 translation product in a sample of extraintestinal tissue and/or body fluids from an individual who is suspected of having stomach or esophageal cancer indicates that the individual has stomach or esophageal cancer.

14. The method of claim 13 wherein the presence of CRCA-1 is detected by polymerase chain reaction wherein said sample is contacted with primers that selectively amplify said CRCA-1 transcript or cDNA generated therefrom.

15. The method of claim 13 wherein said sample is body fluid.

16. The method of claim 13 wherein said sample is body fluid.

17. The method of claim 13 wherein individual is suspected of having stomach cancer.

18. The method of claim 17 wherein individual has been treated for stomach cancer.

19. The method of claim 13 wherein individual is suspected of having esophageal cancer.

20. The method of claim 19 wherein individual has been treated for esophageal cancer.

FIGURE

TGGAGTGGGCTGAGGGACTCCACTAGAGGCTGTCCATCTGGATTCCCTGCCTCCCTAGGAGCCCAACAGAGCAAAGCAAG
TGGGCACAAGGAGTATGGTTCTAACGTGATTGGGGTCATGAAGACGTTGCTGTTGGACTTGGCTTTGTGGTCACTGCTCT
TCCAGCCCGGGTGGCTGTCCTTTAGTTCCCAGGTGAGTCAGAACTGCCACAATGGCAGCTATGAAATCAGCGTCCTGATG
ATGGGCAACTCACCTTTGCGAGCCCTGAATTACTTGAAGATGCAGTGAATGAGGGCTGGAAATAGTGAGAGGACG
TCTGCAAAATGCTGCCTAAATGTGACTGTGAACGCTACTTTCATGTATTCGGATGGTCTGATTCATAACTCAGGCGACT
GCCGGAGTAGCACCTGTGAAGGCCTCGACCTACTCAGGAAAATTTCAAATGCACAACGGATGGGCTGTGTCCTCATAGGG
CCCTCATGTACATACTCCACCTTCCAGATGTACCTTGACACAGAATTGAGCTACCCCATGATCTCAGCTGGAAGTTTTGG
ATTGTCATGTGACTATAAAGAAACCTTAACCAGGCTGATGTCTCCAGCTAGAAAGTTGATGTACTTCTTGGTTAACTTTT
GGAAAACCAACGATCTGCCCTTCAAAACTTATTCCTGGAGCACTTCGTATGTTTACAAGAATGGTACAGAAACTGAGGAC
TGTTTCTGGTACCTTAATGCTCTGGAGGCTAGCGTTTCCTATTTCTCCCACGAACTCGGCTTTAAGGTGGTGTTAAGACA
AGATAAGGAGTTTCAGGATATCTTAATGGACCACAACAGGAAAAGCAATGTGATTATTATGTGTGGTGGTCCAGAGTTCC
TCTACAAGCTGAAGGGTGACCGAGCAGTGGCTGAAGACATTGTCATTATTCTAGTGGATCTTTTCAATGACCAGTACTTG
GAGGACAATGTCACAGCCCCTGACTATATGAAAAATGTCCTTGTTCTGACGCTGTCTCCTGGGAATTCCCTTCTAAATAG
CTCTTTCTCCAGGAATCTATCACCAACAAAACGAGACTTTCGTCTTGCCTATTTGAATGGAATCCTCGTCTTTGGACATA
TGCTGAAGATATTTCTTGAAAATGGAGAAAATATTACCACCCCCAAATTTGCTCATGCCTTCAGGAATCTCACTTTTGAA
GGGTATGACGGTCCAGTGACCTTGGATGACTGGGGGGATGTTGACAGTACCATGGTGCTTCTGTATACCTCTGTGGACAC
CAAGAAATACAAGGTTCTTTTGACCTATGATACCCACGTAAATAAGACCTATCCTGTGGATATGAGCCCCACATTCACTT
GGAAGAACTCTAAACTTCCTAATGATATTACAGGCCGGGGCCCTCAGATCCTGATGATTGCAGTCTTCACCCTCACTGGA
GCTGTGGTGCTGCTCCTGCTCGTCGCTCTCCTGATGCTCAGAAAATATAGAAAAGATTATGAACTTCGTCAGAAAAAATG
GTCCCACATTCCTCCTGAAAATATCTTTCCTCTGGAGACCAATGAGACCAATCATGTTAGCCTCAAGATCGATGATGACA
AAAGACGAGATACAATCCAGAGACTACGACAGTGCAAATACGTCAAAAAGCGAGTGATTCTCAAAGATCTCAAGCACAAT
GATGGTAATTTCACTGAAAAACAGAAGATAGAATTGAACAAGTTGCTTCAGATTGACTATTACACCCTAACCAAGTTCTA
CGGGACAGTGAAACTGGATACCATGATCTTCGGGGTGATAGAATACTGTGAGAGAGGATCCCTCCGGGAAGTTTTAAATG
ACACAATTTCCTACCCTGATGGCACATTCATGGATTGGGAGTTTAAGATCTCTGTCTTGTATGACATTGCTAAGGGAATG
TCATATCTGCACTCCAGTAAGACAGAAGTCCATGGTCGTCTGAAATCTACCAACTGCGTAGTGGACAGTAGAATGGTGGT
GAAGATCACTGATTTTGGCTGCAATTCCATTTTGCCTCCAAAAAAGGACCTGTGGACAGCTCCAGAGCACCTCCGCCAAG
CCAACATCTCTCAGAAAGGAGATGTGTACAGCTATGGGATCATCGCACAGGAGATCATTCTGCGGAAAGAAACCTTCTAC
ACTTTGAGCTGTCGGGACCGGAATGAGAAGATTTTCAGAGTGGAAAATTCCAATGGAATGAAACCCTTCCGCCCAGATTT
ATTCTTGGAAACAGCAGAGGAAAAAGAGCTAGAAGTGTACCTACTTGTAAAAAACTGTTGGGAGGAAGATCCAGAAAAGA
GACCAGATTTCAAAAAAATTGAGACTACACTTGCCAAGATATTTGGACTTTTTCATGACCAAAAAAATGAAAGCTATATG
GATACCTTGATCCGACGTCTACAGCTATATTCTCGAAACCTGGAACATCTGGTAGAGGAAAGGACACAGCTGTACAAGGC
AGAGAGGGACAGGGCTGACAGACTTAACTTTATGTTGCTTCCAAGGCTAGTGGTAAAGTCTCTGAAGGAGAAAGGCTTTG
TGGAGCCGGAACTATATGAGGAAGTTACAATCTACTTCAGTGACATTGTAGGTTTCACTACTATCTGCAAATACAGCACC
CCCATGGAAGTGGTGGACATGCTTAATGACATCTATAAGAGTTTTGACCACATTGTTGATCATCATGATGTCTACAAGGT
GGAAACCATCGGTGATGCGTACATGGTGGCTAGTGGTTTGCCTAAGAGAAATGGCAATCGGCATGCAATAGACATTGCCA
AGATGGCCTTGGAAATCCTCAGCTTCATGGGGACCTTTGAGCTGGAGCATCTTCCTGGCCTCCCAATATGGATTCGCATT
GGAGTTCACTCTGGTCCCTGTGCTGCTGGAGTTGTGGGAATCAAGATGCCTCGTTATTGTCTATTTGGAGATACGGTCAA
CACAGCCTCTAGGATGGAATCCACTGGCCTCCCTTTGAGAATTCACGTGAGTGGCTCCACCATAGCCATCCTGAAGAGAA
CTGAGTGCCAGTTCCTTTATGAAGTGAGAGGAGAAACATACTTAAAGGGAAGAGGAAATGAGACTACCTACTGGCTGACT
GGGATGAAGGACCAGAAATTCAACCTGCCAACCCCTCCTACTGTGGAGAATCAACAGCGTTTGCAAGCAGAATTTTCAGA
CATGATTGCCAACTCTTTACAGAAAAGACAGGCAGCAGGGATAAGAAGCCAAAAACCCAGACGGGTAGCCAGCTATAAAA
AAGGCACTCTGGAATACTTGCAGCTGAATACCACAGACAAGGAGAGCACCTATTTTTAAACCTAAATGAGGTATAAGGAC
TCACACAAATTAAAATACAGCTGCACTGAGGCCAGGCACCCTCAGGTGTCCTGAAAGCTTACTTTCCTGAGACCTCATGA
GGCAGAAATGTCTTAGGCTTGGCTGCCCTGTTTGGACCATGGACTTTCTTTGCATGAATCAGATGTGTTCTCAGTGAAAT
AACTACCTTCCACTCTGGAACCTTATTCCAGCAGTTGTTCCAGGGAGCTTC1ACCTGGAAAAGAAAAGAATTTCATTTAT
TTTTTGTTTGTTTATTTTTATCGTTTTTGTTTACTGGCTTTCCTTCTGTATTCATAAGATTTTTTAAATTGTCATAATTA
TATTTTAAATACCCATCTTCATTAAAGTATATTTAACTCATAATTTTTGCAGAAAATATGCTATATATTAGGCAAGAATA
AAAGCTAAAGGTTTCCCAAAAAAAAAA

Gray Shaded Area -- This is the portion of the sequence that is deleted. One of the boxed G pairs is also deleted.

Start Codon

^ The boxed G nucleotides are to indicate that a pair of G's are deleted. It is difficult to identify which pair is deleted since there are two G nucleotides at the beginning and end of the deleted region.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/29091

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : C12Q 1/68; C12P 19/34
US CL : 435/6, 91.2, 91.21

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 435/6, 91.2, 91.21

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 99/07726 A1 (THOMAS JEFFERSON UNIVERSITY) 18 February 1999, pages 20, 94 and 95.	1-20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 October 2001 (30.10.2001)	03 JAN 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Carla Myers Telephone No. 703-308-0196

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/29091

Continuation of B. FIELDS SEARCHED Item 3:
DIALOG: MEDLINE, CA, BIOSIS, EMBASE, SCISEARCH; WEST: US, EP, WO, JP Patents
search terms: CRCA, CRCA1, colorectoral cancer associated transcript, ST, GCC, guanylyl cyclase C receptor, esophageal, stomach